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Monetary and Labor Policies under Market Frictions

als Inaugural-Dissertation
zur Erlangung des akademischen Grades eines Doktors der Wirtschafts- und Sozialwissenschaften der Wirtschafts- und Sozialwissenschaftlichen Fakultät der Christian-Albrechts-Universität zu Kiel

vorgelegt von

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Contents

List of Tables

List of Figures

Abbreviations (First Part)

AD-AS	aggregate demand / aggregate supply
APW	average productivity worker
AWE	approximately welfare efficient
CAD	current account deficit
DIW	Deutsches Institut für Wirtschaftsforschung
DRTS	decreasing returns to scale
DSGE	dynamic stochastic general equilibrium
ed.	editor
eds.	editors
e.g.	exempli gratia (for example)
est.	estimated
et al.	and others
f.	and the following
FCR	firing cost ratio
FR	firing rate
GDP	gross domestic product
HR	hiring rate
HV	hiring vouchers
IAB	Institut für Arbeitsmarkt- und Berufsforschung
i.e.	id est (that is)
IfW	Kiel Institute for the World Economy
iid	identically and independently distributed
ILO	International Labour Organization
IRF	impulse response function
IS-LM	investment and savings / liquidity demand and money
LAU	low-ability unemployed
LTU	long-term unemployed
LWS	low wage subsidies
NK	New Keynesian
NKPC	New Keynesian Phillips curve

Abbreviations (Second Part)

no.	number
OECD	Organisation for Economic Development and Cooperation
opt.	option
p.	page
pp.	pages
RBC	real business cycle
RR	replacement rate
SE	standard error
SS	self sufficient
s.t.	subject to
viz.	that means
vol.	volume
ZEW	Zentrum für Europäische Wirtschaftsforschung
Δ	difference operator
$\Delta_{t,t+j}$	stochastic discount factor

Roman Letters (First Part)

A, a	productivity
B	bond holdings
b	unemployment benefits
A_{pr} to M_{pr}	coefficients for the linearized primary HR / FR
A_{tr} to M_{tr}	coefficients for the linearized trapped HR / FR
C, c	consumption
co	cost of marginal migrant
d_m	scale factor for money in the utility function
d_e	scale factor for labor in the utility function
d_n	duration dependent employment class
d_u	duration dependent unemployment class
DN	denominator of the price setting equation
E	expectations operator
EC / ED	employment creating / destroying sector
F	non-produced input
f	firing costs
G	government expenditures
g	labor force growth
h	hiring cost
ho	index for households
$_{hi}$	subscript for high ability worker
i	index
j	index
k	index
l	labor force share of a specific ability group
$_{lo}$	subscript for low ability workers
m	real money holdings
M	nominal money holdings
$_{me}$	subscript for medium ability workers

Roman Letters (Second Part)

MC	marginal costs
MI, mi	migration (absolute / divided by labor force)
MRS	marginal rate of substitution
N, n	employment (labor input), employment rate
N^{E1}	primary entrant
N^{E2}	secondary entrant
N^{I}	insider
$_{new}$	subscript for the new steady state
^{no}	superscript for nominal variables
NU	numerator of the price setting equation
P	prices
$_{pr}$	subscript for primary workers
Q	number of matches
R	discount factor
r	nominal interest rate
^{re}	superscript for real variables
rgm	rate of growth of money
rr	replacement rate
s	price distortion term
s^t	history of events
T	lump sum taxes
$T_{\alpha,t}$	Markov matrix of transition probabilities
$_t$	time subscript
TC	total costs
tr	subscript for trapped workers
U, u	unemployment, unemployment rate
U^L	long-term unemployed
U^S	short-term unemployed
Ut	utility

Roman Letters (Third Part)

V	present value of income
Va	number of vacancies
W, w	wage
x	factor for increased labor input
Y	real output

Greek Letters (First Part)

α	share of capital / non-produced input in a Cobb-Douglas function
$_{\alpha_a}$	subscript for ability group
α_1, α_2	superscripts in the matching function
β	subjective discount factor
β_i	ordinary least squares estimator
γ	coefficient for importance of the real wage rigidity
Γ	cumulative function of the operating costs
δ	discount factor
ε_p	elasticity of substitution between different product types
ε_w	elasticity of substitution between different labor types
ζ	time trend of operating costs
η	hiring rate
θ_p	firms' quarterly probability of not re-setting prices
θ_w	households' quarterly probability of not re-setting wages
ι	money demand parameter
κ	output coefficient in the forward looking Phillips curve
λ	Lagrange multiplier
Λ	Nash product
Λ_f	firm's surplus
Λ_w	worker's surplus
μ	bargaining power
μ_p	average mark-up of prices over marginal costs
μ_w	average mark-up of wages over the marginal rate of substitution
ν	utility (of money holdings) parameter
ν_{α_a}	hiring / retention incentive
υ	exogenously given probability of losing productivity
υ_{com}	complementarity measure
ξ	operating cost / random productivity parameter
ξ_u	utility function parameter

Greek Letters (Second Part)

$\widehat{o}_a$	autonomous surplus
$\widehat{o}_n$	induced surplus
π	inflation rate
ρ	firing cost ratio
σ	utility (of consumption) parameter
σ_{α_a}	subsidy
τ	proportional income tax rate
υ	exogenously given probability of losing productivity
φ	disutility (of consumption) parameter
π	inflation
Π	profit
ψ	measure of "quantitative persistence"
ϕ	firing rate
χ	measure for the degree of indexation
ω	money demand parameter
Ω	aggregate welfare
ϖ	exogenously given probability of gaining productivity

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1 Introduction

Macroeconomic theory has changed dramatically during the last couple of decades. While the traditional ad-hoc[1] IS-LM[2] and AD-AS[3] frameworks continue to dominate almost every undergraduate textbook[4], they have virtually disappeared from the recent issues of all major peer-reviewed journals. The Lucas (1976) and Sims (1980) Critiques, the rational expectations revolution and the real business cycle literature have altered the way modern macroeconomic theory is performed, although nowadays none of these theories is considered to be the state of the art. Instead, a new consensus in macroeconomics has emerged, namely the New Keynesian (or New Neoclassical Synthesis) literature. It combines features from traditional macroeconomics and the aforementioned more recent streams. Due to these rapid developments Blanchard (2000, p. 1375) hypothesizes that "progress in macroeconomics may well be the success story of twentieth century economics."

The new modern macroeconomic mainstream differs in two important ways from more traditional approaches:

(i) Microfoundations from first microeconomic principles instead of ad hoc structural equations, which were defended on grounds of their empirical suitability. As inheritance from the famous Lucas (1976) Critique[5], microeconomic optimization and macroeconomic implications have been connected. As a consequence, modern macroeconomic researchers are able to do a welfare analyses of different policy proposals.

(ii) Dynamic (stochastic) general equilibrium (DSGE) modeling under rational expectations instead of a comparative static analysis, which was frequently performed in partial equilibrium frameworks. The DSGE toolkit was the inheritance from the Real Business Cycle (RBC) literature. As a consequence, the interaction between different markets and dynamic adjustment paths has been made visible, thus providing a more complete picture of the

[1] In what follows a framework will be titulated to be "ad hoc" if the macroeconomic relationships are postulated without deriving them from agents' microeconomic optimization.

[2] The IS curve stands for the goods market equilibrium (investment - savings) and the LM curve stands for the money market equilibrium (liquidity demand - money supply) under fixed prices.

[3] Representing aggregate demand and aggregate supply.

[4] See, for example, Blanchard (2005), Mankiw (2005), Neumann (1996) or Wohltmann (2005).

[5] See chapter 2 for details.

economy, for example, with respect to the speed of adjustment and the associated costs of different policies.

The New Keynesian literature originated with works by Blanchard and Kiyotaki (1987), Calvo (1983) and Taylor (1980), among others, who introduced several market frictions into the RBC framework (e.g., monopolistic competition, menu costs, staggered prices and wages). This dissertation hypothesizes that these frictions do not go far enough yet. They do not give sufficient attention to (i) the interaction among different types of nominal frictions and potential complementarities, (ii) the role of labor turnover costs, wage bargaining and other labor market frictions in determining macroeconomic performance and (iii) policy implications of these frictions. This dissertation sheds lights on all of these issues. It models several frictions and derives the implications thereof, namely the interaction of nominal price and wage rigidities, a real wage rigidity, hiring and firing costs and wage bargaining. Two chapters rather fit into the New Keynesian monetary economics literature (analyzing the effects of monetary policy), while three are closer to the macro-labor literature (analyzing the effects of different labor market policies).[6] In chapters 3 to 7 different dynamic macroeconomic models are derived from agents' profit and utility maximization[7] (micro-foundation) who take the existing market frictions into account. The models are calibrated numerically and the macroeconomic effects of different policies are derived.

The book is structured as follows: Chapter 2 reviews recent developments in macroeconomic and labor theory. It shortly surveys the path of modern macroeconomics from the IS-LM model to the New Neoclassical Synthesis and points out well-known weaknesses and potential solutions, thus introducing chapters 3 and 4. Furthermore, chapter 2 provides a short overview of the state of the art in the macro-labor theory and potential weaknesses, serving as a door opener for chapters 5 to 7.

Chapter 3 analyzes complementarities between price and wage staggering in the well-known Calvo (1983) framework. These complementarities were so far ignored by the New Keynesian literature. Furthermore, it questions the general view that wage staggering generates more persistence than price staggering,

[6] The distinction between labor and monetary economics may not be relevant any more when these lines come to the eyes of the reader. Recently, these two streams of literature have converged very quickly. See, for example, Christoffel and Linzert (2005), Krause and Lubik (2007) or Trigari (2004).

[7] In all chapters it is assumed that agents follow the rational expectations hypothesis. Thus, it is not possible for policy makers to cheat the economic agents, for example, through money illusion.

by defining a new persistence measure. Chapter 4 analyzes the effects of a real wage rigidity on disinflations and challenges the view that a real wage rigidity is necessary to obtain a realistic disinflationary output slump.

Chapter 5 introduces a new dynamic labor market framework and calibrates it for the East German labor market after reunification. Furthermore, the idea of labor market traps is explained intuitively. Chapter 6 extends the simple homogenous labor market framework to the case with low productivity labor market traps. It calibrates the more sophisticated model for East Germany and performs several exercises in order to see how East Germany's labor market may be kick-started. In chapter 7 the simple model from chapter 5 is extended to a more heterogenous labor market with three exogenously given ability groups and endogenous human capital movement, which depends on the (un-)employment duration, thus providing a more complete picture of the labor market. The framework is used in order to evaluate differently targeted employment subsidies which are currently discussed in the political debate in Germany. Finally, the thesis concludes and gives a tentative outlook for future research developments.

2 Modern Macroeconomic and Labor Theory

2.1 Macroeconomic Theory

2.1.1 The Path to the New Synthesis

This subsection provides a short description of the developments in macroeconomic theory (specifically in monetary economics) during the last couple of decades. It is only meant to be an appetizer and it heavily borrows from Blanchard (2000), Goodfriend (2007), Goodfriend and King (1997), Gottschalk (2005) and Mankiw (1990). Readers who get hungry by this appetizer are referred to these authors.

As mentioned above, the monetary framework of the 1950s and 1960s, the old neoclassical synthesis (well known through the famous IS-LM model), can still be found in most undergraduate textbooks. However, during the 1970s it lost its appeal due to empirical and theoretical weaknesses. "The empirical flaw was that the consensus view could not adequately cope with the rising rates of inflation and unemployment experienced during the 1970s. The theoretical flaw was the consensus view left a chasm between microeconomic principles and macroeconomic practice (...)." (Mankiw, 1990, p. 1647).

The monetarist theory prepared the funeral for the old neoclassical synthesis. In his presidential address to the American Economic Association Friedman (1968)[8] challenged the view that there is a stable long-run trade-off between inflation and real economic activity. Friedman proposed the idea of a steady state unemployment rate (the "natural rate of unemployment") which is independent of the inflation rate. However, most monetarists acknowledged the short-run nonneutrality of money, without having a sound theoretical underpinning for it. They attributed it to short-run price stickiness and expectational errors[9]. Gurley (1961, p. 308) points out this theoretical shortcoming: "Money is a veil, but when the veil flutters, real output sputters."

The rational expectations revolution puts the final nails into the old neoclassical synthesis' coffin, most famously with the seminal work of Lucas (1976). He states that it is crucial to take the behavioral reaction of economic agents into account when analyzing different economic policies. Rational agents will adjust their behavior to altered circumstances. As a consequence, the structural equations which are derived from empirical work, cannot be used for

[8]See Phelps (1968) for a similar reasoning.

[9]For details see Goodfriend and King (1997, p. 8 f.) or Cahuc and Zylberberg (2004, p. 471 f.).

policy evaluation, as they may lack stability. Along these lines Sims (1980) criticizes the way traditional macroeconometric models are identified empirically (via untested a priori restrictions).

In the light of the destruction of the stable inflation-output trade-off view, the real business cycle theory developed an alternative explanation for economic fluctuations, namely exogenous variations in technology (see Kydland and Prescott, 1982, and King, Plosser and Rebelo, 1988a and b). The prevailing view of RBC modelers said that technology shocks "account for more than half the fluctuations in the postwar period with a best point estimate near 75%."[10] The RBC theory used a perfect competition environment and, thus, monetary policy had no role to play. But the view that the business cycle is almost entirely driven by technology shocks is very much at odds with empirical evidence.[11] And the "policy ineffectiveness proposal"[12] (the view that monetary policy or any government policy in general is ineffective) does not only stand in contrast to central bankers' perception, but also to empirical evidence, e.g. from Vector-Autoregressions.[13]

Interestingly, rational expectations and the real business cycle theory laid an important groundwork for the New Keynesian theory, which originated with the inflexible price/wage adjustment mechanisms by Calvo (1983) and Taylor (1980), and the monopolistic competition framework by Blanchard and Kiyotaki (1987). "While most macroeconomists have recognized the methodological impact of the RBC research program and have adopted its modeling tools, other important, more substantive elements of that program have been challenged in recent years." (Galí and Rabanal, 2004, p. 225). The ingredients of the New Keynesian literature will be shortly reviewed in the next subsection.

2.1.2 Main Components

Policy makers only have a role to play if market frictions, which were absent in the RBC literature, are introduced into the dynamic stochastic general equilibrium (DSGE) framework, which became a standard tool of business cycle analysis through the RBC literature. Blanchard and Kiyotaki (1987) delivered important foundations for the New Keynesian theory, with a combination of constant elasticity of substitution monopolistic competition[14] and menu costs.

[10] Galí and Rabanal (2004, p. 225)

[11] For a recent survey see Galí and Rabanal (2004).

[12] See, for example, Sargent and Wallace (1975).

[13] See, e.g., Christiano et al. (2005) or Angeloni et al. (2003).

[14] See Dixit and Stiglitz (1977).

The state of the art New Keynesian models contain the following components (see, for example, Galí, 2003, Clarida et al., 1999, Walsh, 2003, Woodford, 2003, for very comprehensive summaries):

- rational expectation formation
- dynamic general equilibrium analysis
- derivation from first microeconomic principles
- market clearing
- monopolistic competition
- adjustment costs or staggered prices and / or wages

Thus, the New Keynesian literature combines elements from different competing schools of thought, namely rational expectations, (neo-)classical economics (market clearing) and RBC literature (dynamic general equilibrium analysis and the modeling tools). Monopolistic competition and non-flexible price / wage adjustment add the Keynesian components. Among the nominal rigidities, Calvo's (1983) stochastic[15] adjustment mechanism ranks most famously, which can be attributed to its analytical simplicity and the resulting price distribution. The Calvo scheme delivers more dispersed prices than the deterministic Taylor staggering[16] and thus, the price distribution is closer to the empirical evidence.

2.1.3 Problems and Potential Solutions

The standard microfounded DSGE model (which does not use ad hoc assumption on a microeconomic level, but derives all macroeconomic equations from firms' profit and households' utility maximization) is usually associated with the following two problems[17]: (i) a lack of inflation and output persistence (plus implausible output responses), (ii) disinflationary booms.[18]

[15]Prices / wages can be adjusted with an exogenously given probability every period. Alternatively, but less frequently, Taylor's (1980) deterministic approach or Rotemberg's (1983) adjustment costs are used.

[16]If θ_p is the quarterly probability of not re-setting prices, after n periods, there remains a fraction θ_p^n of firms which was not able to re-set prices. Thus, other than under Taylor contracting, there is always a small fraction of firms which have not been able to re-set prices for a long time. For an intensive discussion of the implications of Calvo price adjustment versus Taylor staggering see Kiley (2002) and Dixon and Engin (2006).

[17]See Mankiw (2001, p. 53 ff.) for a discussion of these phenomena.

[18]Estrella and Fuhrer (2002) point out further counter-factual implications of this class of models.

Lack of Inflation and Output Persistence: Fuhrer and Moore (1995, p. 129) point out[19] that "all of the persistence in inflation derives from the persistence in the driving term y_t. Thus, a one-period shock to output will affect inflation for one period only; the contracting specification adds no inflation persistence of its own. (...) Unless the shock itself persists, the effect on inflation will not persist." While prices are a predetermined variable in New Keynesian models, the inflation rate is a jump variable[20] and, thus, the latter does not show persistence (in contrast to the empirical evidence).

Chari et al. (2000) construct a dynamic general equilibrium model with Taylor type price staggering and conclude that this type of model is not able to generate sufficient degrees of endogenous output persistence: "We find that for a wide range of parameter values, the amount of endogenous stickiness is small. Thus, we find that in a standard quantitative model, staggered price-setting, alone, does not generate business cycle fluctuations." (Chari et al., 2000, p. 1151) Huang and Liu (2002) use the Taylor framework as well and write that: "With reasonable values of parameters in preferences and technologies, staggered price-setting by itself is incapable of [generating persistence], while staggered wage-setting has a great potential in generating real persistence (...)." (p. 407) We will re-consider this issue in chapter 3.

Recent works (e.g., Christiano et al., 2005, Smets and Wouters, 2003) have tried to solve these problems (lack of inflation and output persistence) by introducing a set of ad hoc assumptions on the microeconomic level, for example, habit formation by households[21], indexation of prices[22] and artificial timing assumptions[23]. In a new approach, Altig et al. (2005) reconcile microeconometric evidence on price stickiness[24] and macroeconometric inflation

[19] Fuhrer and Moore (1995) refer to the standard forward looking Phillips curve ($\pi_t = E_t\pi_{t+1} + \kappa y_t$), where π is the inflation rate (in period $_t$ and $_{t+1}$) and y is the output gap, derived from Taylor (1980) two period contracting.

[20] Formally, the eigenvalue of a jump variable is greater than one, while the one for a predetermined variable is smaller than one (see, for example, Gandolfo, 2003).

[21] Consumption is not determined by the optimization of a standard utility function. But the lag of consumption is added in the utility function: $E_t \sum_{i=0}^{\infty} \beta^i \left[Ut\left(C_{t+i} - bC_{t+i-1}\right) - Ut\left(N_{t+i}\right) + Ut\left(m_{t+i}\right)\right]$, where C is consumption, N is labor input and m are the real money balances (see e.g. Christiano et al., 2005).

[22] Prices that cannot be re-optimized are adjusted automatically, by indexing them to the past or steady state inflation rate. If a firm j is not able to re-adjust prices in period t and indexes to past inflation, its prices (P) develop as follows: $P_{j,t} = \pi_{t-1}P_{j,t-1}$, where π_{t-1} is the inflation rate of the previous period.

[23] It is assumed that the agents react with a specific time lag to certain shocks.

[24] See Bils and Klenow (2004) for US evidence and Stahl (2005) for German evidence. The US evidence suggest that price are adjusted very frequently, viz. on average about every second quarter.

persistence by introducing firm-specific capital. "In standard equilibrium business cycle models a firm's capital stock is not pre-determined and all factors of production, including capital, can be instantaneously transferred across firms, without any cost, in perfectly competitive markets. (...) In our model, a firm's capital is pre-determined and can only be changed over time by varying the rate of investment." (Altig et al., 2005, p. 2)

Disinflationary Booms: The problem of disinflationary booms was popularized by Ball (1994). While empirically disinflations are associated with considerable output slumps[25], Ball (1994) shows that New Keynesian models may generate a boom if a credible future disinflation is announced. In anticipation of a credible disinflation, price setters adjust prices downwards before the growth of the nominal money balances is reduced, thus causing a temporary increase in real money balances and an economic boom. In a recent paper, Trabandt (2006)[26] shows that disinflationary booms, as shown in Ball (1994), are due to the specific money demand and the partial equilibrium nature. They disappear in a fully fledged DSGE model.

Relation to the Thesis: Chapter 3 and 4 contribute to the aforementioned literature and try to clarify some misconceptions. Chapter 3 belongs to the literature stream, which analyzes the output persistence after a monetary shock. It explores the influence of price and wage staggering on monetary persistence. We show that, for plausible parameter values, wage and price staggering are highly complementary in generating monetary persistence. We do so by proposing the new measure "quantitative persistence," after discussing weaknesses of the "contract multiplier,"[27] which is generally used to compare persistence. The existence of complementarities means that beyond understanding how price and wage staggering work in isolation, it is important to explore their interactions. Furthermore, our analysis indicates that the degree of monetary persistence generated by wage vis-à-vis price staggering depends crucially on the relative competitiveness of the labor and product markets. We show that the conventional wisdom that wage staggering can generate more persistence than price staggering does not necessarily hold.

[25] See e.g. Ball (1993).

[26] While Trabandt (2006) uses the Calvo price adjustment, a similar point is made in Ascari (1998) with Taylor wage staggering. However, as will be shown in chapter 4, there remain misconceptions about disinflations in DSGE models among economists.

[27] See Huang and Liu (2002, p. 408) who define the contract multiplier as "the ratio of output response at the end of the initial contract duration to that in the impact period."

Chapter 4 belongs to the stream of literature which analyzes disinflations in New Keynesian workhorse models. It examines the cost of disinflation under real wage rigidities in a micro-founded New Keynesian model. Other than Blanchard and Galí (2007) who did the same in a linearized framework, we take non-linearities into account. We show that the results both qualitatively and quantitatively change dramatically both for the steady states and for the dynamic adjustment paths. Moreover, a disinflation implies a prolonged slump without any need for real wage rigidities.

2.1.4 Unemployment in Workhorse New Keynesian Models

In the standard New Keynesian models (e.g., Clarida et al., 1999, Galí, 2003, Woodford, 2003) there is no unemployment at all. The labor market is (neo-) classical. Thus, the labor supply is given by the households' intertemporal utility maximization and the labor demand is given by the firms' profit maximization. A restrictive monetary policy leads to a temporary drop in labor demand, which equals labor supply at any point in time. Quite often, the temporary reduction in working hours for each worker (compared to the natural level[28]) is interpreted as unemployment. Van der Ploeg (2005, p. 811) points out that the nature of underemployment in New Keynesian models is quite different from reality. In central European countries about 10 percent of the active labor force are registered as unemployed, some of them for very protracted periods of time: e.g., in Germany the proportion of long term unemployed[29] (among all unemployed) is roughly 50 percent (Sachverständigenrat, 2004). Thus, other than in the New Keynesian models in reality unemployment is distributed very unequally.

Possibly, the approximation to use underemployment instead of unemployment is not even innocuous for monetary policy analysis and may be the root of the problems that were pointed out above, e.g., the lack of inflation persistence and implausible impulse response function. But for the analysis of non-monetary policies (for example labor market measures) the New Keynesian short-cut to interpret the deviation from the natural level of employment as unemployment may lead to very biased theoretical results. It ignores important phenomena, which are well known from the labor literature, such as human capital attrition, insider power, wage bargaining or efficiency wages (see section below).

[28] As described above, the natural rate idea goes back to Phelps (1968) and Friedman (1968).

[29] Defined as unemployment for more than one year.

It would be very desirable to move towards a more unified macro-labor framework (in order to analyze different policies), which takes the lessons of recent macroeconomic theory into account, namely rational expectations, derivation of macroeconomic implications from agents' intertemporal profit maximization, general equilibrium and the RBC toolkit. This may not only be helpful to solve some of the major problems in monetary economics, which are described above. But it would also provide more insights about the interaction of different markets, policies and complementarities thereof.

In recent years there have been two major tendencies in order to enable the New Keynesian framework to analyze a set of different policies:

On the one hand, the set of new ad hoc assumptions has been inflated to approach the theoretical responses to the empirical evidence. Galí et al. (2007) introduce, for example, so called "rule of thumb" consumers, i.e. consumers that live in "hand-to-mouth" fashion and do not save at all. Thus, these households[30] do not base their consumption decision on the intertemporal budget constraint, i.e. they do not behave in pure Ricardian fashion[31]. By introducing this ad hoc assumption, the modeled theoretical reactions to fiscal policy come closer to the empirical evidence.[32] Although the micro-founded dynamic general equilibrium models were introduced to overcome the Lucas Critique, they increasingly run afoul of it in their recent specifications.

On the other hand, labor market frictions are introduced into the standard New Keynesian model, thus deviating from the neo-classical labor market (e.g., Blanchard and Galí, 2006 and 2007, Christoffel and Linzert, 2005, Krause and Lubik, 2007, and Trigari, 2004). However, most current approaches[33] use the search and matching model, going back to Mortensen and Pissarides' (1994) seminal work, which may also be subject to the Lucas Critique (1976). The next section will review recent developments in the macro-labor theory and point out potential limitations of the search and matching theory.

2.2 State of the Art in Macro-Labor Theory

The (neo-)classical labor market theory (as used in the New Keynesian theory) has very important empirical and theoretical caveats. As mentioned

[30] Galí et al. (2007) assume a certain fraction of all households follow "rule of thumb" behavior.

[31] For the "Ricardian equivalence" see Barro (1974).

[32] For other ad hoc assumptions see Christiano et al. (2005) and Smets and Wouters (2003), which are shortly discussed above. The ad hoc assumptions are defended on grounds of a better fit with the empirical evidence.

[33] For an exception see Danthine and Kurmann (2004) who use an efficiency wage approach.

above, there is no involuntary unemployment[34], but only voluntary inactivity of workers. Rationally optimizing agents choose not to supply their labor at the prevailing market wage. In light of considerable unemployment rates in continental Europe, this is very difficult to accept. For a review of empirical shortcomings of the neoclassical labor market model see, for example, Cahuc and Zylberberg (2004, p. 459 f.).

In reaction to the deficiencies of the neoclassical labor market, during the 1980s numerous theories have evolved which explain why the actual wage may be above the neoclassical market clearing level. Most of the contributions either belong to the efficiency wage or insider-outsider literature. Two famous examples will shortly be described below.

Efficiency Wages: Efficiency wage models usually need two ingredients: a principal-agent problem and moral hazard. The principal (employer) and the agent (employee) agree on a certain labor contract. If there is asymmetric information, e.g. the employer is not able to monitor the effort of the employee perfectly, there arises a moral hazard problem, i.e. the employee may provide less effort than she committed to. The intuition for involuntary unemployment in Shapiro and Stiglitz's (1984, p. 433)[35] model runs as follows: "Under the conventional competitive paradigm, in which all workers receive the market wage and there is no unemployment, the worst that can happen to a worker who shirks on the job is that he is fired. Since he can immediately be rehired, however, he pays no penalty for his misdemeanor. (...) To induce its workers not to shirk, the firm attempts to pay more than the "going wage": then, if a worker is caught shirking and is fired, he will pay a penalty. If it pays one firm to raise its wage, however, it will pay all firms to raise the wages. (...) But as all firms raise their wages, their demand for labor decreases, and unemployment results." Shapiro and Stiglitz's (1984) model is criticized for its stationary nature, which restricts the wage profile to be constant over time, yielding only a very specific case.[36]

[34]The term "involuntary unemployment" was popularized by Keynes (1936). In what follows it is used, as defined by Snower and Lindbeck (1988b, p. 105): "A worker is involuntarily unemployed over a particular period of time if he does not have a job during that period, even though he would wish to work at an efficiency wage that is less than the efficiency wage of a current employee, provided that he had the opportunity to be employed under identical conditions of employment as the emplyoee." For a discussion of "involuntary unemployment" see De Vroey (2004).

[35]There are numerous other efficiency wage type models, which - for the sake of brievity - will not be discussed.

[36]See Cahuc and Zylberberg (2004, p. 353 f.) for more details.

Insider versus Outsiders: Lindbeck and Snower (1985, 1988a) develop the insider-outsider theory which claims that labor turnover costs (hiring costs, firing costs or cost of training) create economic rents which are extracted by insiders in wage negotiations. The insiders, who are protected by labor turnover costs or who can use labor harassment (withdraw cooperation) to reduce the productivity of potential wage underbidders, will agree on a higher wages with the employer than under a neoclassical labor market. Thus, as in the efficiency wage theory, due to too high wages, involuntary unemployment will arise. Similar to the efficiency wage theory, the original insider-outsider theory has been criticized on ground of its static nature and simplifying assumptions.[37]

Search and Matching: Recently, labor market theory has shifted away from its static predecessors to dynamic approaches. The search and matching approach by Mortensen and Pissarides (1994) has emerged to be the new mainstream tool for the explanation of unemployment and for the analysis of different labor market policies.[38]

The search and matching theory assumes that there is a well-behaved matching function, where the number of matches in the labor market (Q) is a function of unemployment and vacancies ($Q = f(U, Va)$), where U is the number of unemployed workers and Va is the number of vacancies. The matching function is typically specified in Cobb Douglas form ($Q = U^{\alpha_1} Va^{\alpha_2}$).

"The *matching function* goes straight to an *aggregate level* (for example, a country region, or industry) and does not take into account the diversity of individual actions." (Cahuc and Zylberberg, 2004, p. 518). Petrongolo and Pissarides (2001, p. 424) write that "the matching function is a black box: we have good intuition about its existence and properties but only some tentative ideas about its microfoundations."

In light of the Lucas Critique it is of course highly doubtable to use a black box specification for policy analysis. As with the old style IS-LM model, the data may seem to be in accordance with the search and matching function. But under different policies, rational agents may adjust their behavior and thus change the search and matching process substantially. Various empirical studies cast some doubt on the stability of the search and matching function (see below).

Frequently, the Mortensen and Pissarides' (1994) search and matching framework is used to analyze the effect of different employment policies (see,

[37] For a discussion see Fehr (1990) and Lindbeck and Snower (1990).

[38] See Pissarides (2000) for a comprehensive text book.

e.g., Boone and van Ours, 2004, Bovenberg et al., 2000, Cardullo and van der Linden, 2006, Mortensen and Pissarides, 2003, Pierrard, 2005, and Vereshchagina, 2002). The matching technology - describing the relation between the inputs and output of the matching process - is assumed to be stable through time. This assumption is admissible provided that the matching technology (described by the functional form of the matching function) can be considered independent of the inputs and output of the matching process. However, very often a negative time trend is found when estimating the search and matching function, thus casting doubt on the stability through time (Blanchard and Diamond, 1989, for the United States, and Fahr and Sunde, 2001 and 2004, for Germany).[39] It is admissible to use the matching function to analyze labor market policies, provided that these policies have no significant influence on the matching process itself. However, we do not see a rationale why active labor market policies should not affect the matching process.

Relation to the Thesis: In order to prevent running afoul of the Lucas Critique, we do not take the aforementioned short-cut.[40] Instead, we derive the policy effects in a microfounded way from the intertemporal maximization of economic agents and model their incentives explicitly. We give special emphasis to the firm side in our model since labor demand is the short side of the market in economies with stellar unemployment. The household side comes into play through the wage formation.

Chapter 5 develops a simple micro-founded framework and applies it to the situation in East Germany after unification. The East German labor market has hardly made any progress since German reunification, despite massive migration flows and support from the West. We argue that East Germany is in trouble precisely because of the support it has received. The chapter explores the phenomenon of "the caring hand that cripples," arising from bargaining by proxy, the adoption of the West German welfare system and the associated employment persistence. Even the steady decrease of labor cost (normalized by productivity) since the beginning of the 1990s did not help to kick start

[39] Furthermore, many empirical studies reject the hypothesis of constant returns to scale (e.g. Warren, 1996, for the United States, Fahr and Sunde, 2001, for Germany). The number of matches (Q) is a function of unemployment and vacancies ($Q = f(U, Va)$), typically specified in Cobb Douglas form ($Q = U^{\alpha_1} Va^{\alpha_2}$). If $\alpha_1 + \alpha_2$ do not sum up to 1, the results are input dependent.

[40] Furthermore, in contrast to a big part of the search and matching literature, we use an endogenous job destruction rate. It can e.g. be expected that a wage subsidy reduces the firing rate, while a hiring subsidy does not do so. Omitting this feature would bias the results.

the East. We suggest that labor force participants fell into "traps," concerning low skills, aging of the workforce, labour-saving capital and skills, capital underutilization, and unemployment arising from the decline of the tradable sector. However, we do not model these labor markets formally yet.

Chapter 6 extends the framework to a dual labor market, with a high productivity (primary) sector and a low productivity (secondary) sector where the movement between these two sectors is endogenous, thus formalizing labor market traps. The framework is used to analyze different policies to kick-start East Germany. More generally, the chapter addresses the question of why prolonged regional unemployment differentials tend to persist even after their proximate causes have been reversed (e.g., after wages in the high-unemployment regions have fallen relative to those in the low-unemployment regions). We suggest that the longer people are unemployed, the greater is the likelihood of falling into a low-productivity "trap," through the attrition of skills and work habits. We develop and calibrate a model along these lines for East Germany and examine the effectiveness of three employment policies in this context: (i) a weakening of workers' position in wage negotiations due to a drop in the replacement rate or firing costs, leading to a fall in wages, (ii) hiring subsidies, and (iii) training subsidies. We show that the employment effects of these policies depend crucially on whether low-productivity traps are present.

Chapter 7 develops a more detailed labor market with three ability groups which are exogenous and endogenous skill acquisition / attrition through on-the-job training / unemployment. It provides a theoretical and quantitative analysis of various types of well known employment subsidies. Two important questions are addressed: (i) How should employment subsidies be targeted? (ii) How large should the subsidies be? We consider measures involving targeting workers with low incomes/abilities and targeting the unemployed. To make our analysis particularly useful to policy makers, we focus on policies that are "approximately welfare efficient," i.e. policies that (a) improve employment and welfare, (b) do not raise earnings inequality and (c) are self-financing. This criterion enables us to identify policies which satisfy these favorable properties and to determine the size of the subsidies required for this purpose. The calibration shows that hiring vouchers targeted at the long-term unemployed and low-income/ability workers can be approximately welfare efficient, while low-wage subsidies do not satisfy this criterion. Even in terms of inequality reduction low-wage subsidies are outperformed by targeted hiring vouchers.

Furthermore, hiring vouchers targeted at the long-term unemployed are more effective than hiring vouchers targeted at low-income/ability workers. These subsidy rankings also hold if the self-financing constraint is relaxed and the government spends a given additional amount on the subsidies.

3 Monetary Persistence and Staggering Complementarities

3.1 Introduction

We show in this chapter[41] that, for plausible parameter values, wage and price staggering are highly complementary in generating persistent output effects in response to monetary policy shocks. In other words, the joint effect of wage and price staggering on monetary persistence is larger than the sum of the individual effects. Thus the comparisons between the effects of wage and price staggering, which are so common in the New Keynesian literature, are only of limited usefulness. Clearly, the larger the complementarities between wage and price staggering are, the less important it is to know how wage and price staggering work in isolation and the more important it is to explore their interactions. This result deserves attention because, in practice, it is very common for nominal wages and prices *both* to be set for finite periods of time (see, for example, Christiano et al., 2005, Erceg et al., 2000, Smets and Wouters, 2003).

In evaluating the relative effects of wage and price staggering on monetary persistence, as well as their joint effects, the production technology turns out to be important. Since the real effects of temporary monetary shocks work themselves out over the short run, it is natural to assume that firms face diminishing returns to labor - also a primarily short-run phenomenon. We show that the more rapidly diminishing the returns to labor are, the more the relative competitiveness of the product and labor markets matters for the relative monetary persistence generated by wage and price staggering. Our analysis indicates that, for plausible technological parameter values, the relative competitiveness has a sizeable influence on the relative monetary persistence.

In order to understand the complementarities, it is necessary to analyze the individuals effects of wage and price staggering. In the recent New Keynesian literature, a large body of articles argues that wage staggering generates more monetary persistence than price staggering in response to monetary policy shocks (i.e. the real effects of temporary monetary shocks are more persistent when wages are set through overlapping nominal contracts than when prices are set in this way), see e.g. Andersen (1998), Huang and Liu (2002) and

[41] For a different version of this chapter see "Monetary Persistence, Imperfect Competition and Staggering Complementarities," with Dennis Snower, CEPR Discussion Paper, No. 5658, May 2006.

Kim (2003). This chapter calls this conventional wisdom into question. It shows that the relative strength of monetary persistence generated by wage vis-à-vis price staggering depends on the relative competitiveness of the labor and product markets. In particular, the more competitive the product market is relative to the labor market, the more monetary persistence is generated by price relative to wage staggering. We show that if the product market is sufficiently more competitive than the labor market, price staggering makes the real effects of temporary monetary shocks more persistent than does wage staggering. This result is potentially important because, in practice, product markets are often more competitive than labor markets. There are various obvious reasons for this, e.g. employers often find it more costly to switch between employees than consumers find it to switch between products.

In this context, it turns out to be useful to think carefully about how we measure monetary persistence. The effects of a monetary shock on real economic activity through time (e.g. the effects of a temporary increase in money growth on national output) can be described by the relevant impulse response function (IRF). The "degree of monetary persistence" is a summary statistic of this function. The standard statistic, which is generally used in the New Keynesian literature, is the "contract multiplier," usually defined as the ratio of the response after the contract duration has elapsed to the response in the impact period (see e.g. Huang and Liu, 2002). In other words, this summary statistic measures how much the response dies out within a given span of time.

While the contract multiplier captures one feature of the IRF, it misses other important ones. Suppose, for example, that wage and price staggering were associated with IRFs (of output to a given monetary shock) that differed only by an additive constant. This difference, however large, would not be identified by the contract multiplier, because both IRFs have the same slope at every point in time, and thus the ratio of the response in period 1 and period t would be the same. To capture this difference, it is convenient to use a measure that we call "quantitative persistence:" for a temporary unit shock in period 1, it is the sum of the output responses from period 2 onwards. In words, quantitative persistence measures by how much output changes, in total, after the monetary shock has disappeared. This measure of monetary persistence turns out to be particularly useful in describing how wage and price staggering affect monetary persistence. It is also useful in capturing the complementarities between wage and price staggering in generating monetary persistence.

This chapter is organized as follows. Section 2 presents the underlying dynamic general equilibrium models, which are standard New Keynesian models with Calvo staggering. In order to understand the complementarities, it is necessary to look at the relative strength of monetary persistence individually first and jointly thereafter. Section 3 describes, formally and intuitively, how the relative strength of monetary persistence generated by wage vis-à-vis price staggering depends on the relative competitiveness of the labor and product markets. Section 4 derives the complementarities between wage and price staggering in generating monetary persistence. Section 5 relates our results to the existing literature. Section 6 concludes.

3.2 Models of Wage and Price Staggering

Our model economies each contain households, firms and a government. The government prints money and bonds and imposes taxes/transfers on the households.[42] Our models of wage and price staggering are completely standard Calvo (1983) models. The model is linearized around a zero money growth steady state. Monetary shocks are generated when the monetary authority (government) increases the money supply and the economic agents do not know the shock until it occurs. We will discuss the effects of a one time increase of the money supply by 1%,[43] which is transferred from the monetary authority to the households in a lump-sum manner ("helicopter drop of money").

In the model of wage staggering, there is a continuum of households supplying differentiated labor and the firms produce output by means of all the labor types. These labor types are imperfect substitutes in production (as in Blanchard and Kiyotaki, 1987). The households' wage setting is randomly staggered, with each household having a fixed probability of changing its wage in any given period of time. The wages are set to maximize the households' utility, subject to their budget constraints and labor demand functions. The firms maximize their profits instantaneously with respect to employment and output, subject to their production functions.

[42] Without loss of generality we assume no government consumption. If we assumed that the government consumes a constant fraction of each good, which is financed via lump-sum taxation, we would obtain a similar dynamic system. Calculations are available on request.

[43] In most other papers the money growth follows an autoregressive process. We however do not consider autocorrelations of the money supply, as we seek to identify the endogenous persistence generated by the behavior of the model (rather than the persistence of the shocks). As Taylor noted, "leaving all the persistence of inflation to exogenous serial correlation is not a completely satisfactory conclusion" (Taylor, 1999, p. 1040).

In the model of price staggering, firms supply a continuum of goods to the households. These goods are imperfectly substitutes in consumption. The firms' price setting is randomly staggered. The prices are set to maximize the firms' profits, subject to their production functions and their product demand functions. The households maximize their utility instantaneously with respect to consumption, labor, real money balances and bond holdings, subject to their budget constraints.

In the first step, we derive the dynamic system for wage staggering, with the purpose to generate IRFs. Thus we will be able to compare them to IRFs for price staggering, which will be generated from the according dynamic system afterwards.

3.2.1 Wage Staggering

Firms: The product market is perfectly competitive. There is a fixed number of identical firms (normalized to unity), producing a homogeneous product. The firms are price-takers. Firms face the following short-run Cobb-Douglas type production function:[44]

$$Y_t(j) = A_t N_t(j)^{1-\alpha} \tag{1}$$

where j is the index for the firm, Y_t is the level of production, A_t is a productivity parameter, N_t is the labor input, and α denotes how significant the diminishing returns to labor are.[45]

Under perfect competition, prices are set uniformly and are equal to marginal costs:

$$P_t = MC_t^{no} \tag{2}$$

where P_t is the aggregate price level and MC_t^{no} are the nominal marginal costs.

Households: The aggregate labor input is a Dixit-Stiglitz function of a continuum of individual labor inputs (normalized to unity):

[44] We use the following terminology. Capital letters are level variables (Y_t), lower case letters denote logarithmic variables (y_t), lower case letters with a bar ($\bar{y}$) denote the variable at the steady state and lower case variables with a tilde ($\tilde{y}_t$) denote deviations from the steady state.

[45] As the effect of monetary shocks work themselves out over the short run, we assume a fixed amount of capital. Many recent papers assume full mobility of capital. Altig et al. (2005, p. 2) comment this approach as "empiricially unrealistic but [it is] defended on the grounds of tractability. The hope is that these assumptions are innocuous and do not affect major model properties. In fact these assumptions matter a lot."

$$N_t = \left[\int_{ho'=0}^{1} N_t\left(ho'\right)^{\frac{\varepsilon_w - 1}{\varepsilon_w}} \, dho' \right]^{\frac{\varepsilon_w}{\varepsilon_w - 1}} \tag{3}$$

where $N_t(ho)$ is the amount of labor chosen from household ho and ε_w is the elasticity of substitution between different labor types.

Minimizing the firm's labor cost, we obtain its labor demand function for each labor type:

$$N_{t+i}(ho) = \left(\frac{W_t^*(ho)}{W_{t+i}} \right)^{-\varepsilon_w} N_{t+i} \tag{4}$$

where $W_t^*(ho)$ is the optimal wage set by household ho in period t. The corresponding aggregate wage index W_{t+i} is defined as

$$W_{t+i} = \left[\int_{ho'=0}^{1} W_{t+i}\left(ho'\right)^{1-\varepsilon_w} \, dho' \right]^{\frac{1}{1-\varepsilon_w}} . \tag{5}$$

The household's utility is $Ut(C_{t+i}(ho)) - Ut(N_{t+i}(ho)) + Ut(M_{t+i}(ho)/P_{t+i})$, $Ut' > 0$, $Ut" < 0$, where $C_{t+i}(ho)$ is its consumption,[46] $N_{t+i}(ho)$ is its employment, and $M_{t+i}(ho)/P_{t+i}$ are its real money balances. In each period the wages can be reset with probability $(1-\theta_w)$.

The household maximizes its utility in a Calvo setting[47]

$$Ut\left(C_t(ho), \frac{M_t(ho)}{P_t}, N_t(ho) \right) = \frac{C_t^{1-\sigma}(ho)}{1-\sigma} + \frac{\left(\frac{M_t(ho)}{P_t}\right)^{1-\nu}}{1-\nu} - \frac{N_t^{1+\varphi}(ho)}{1+\varphi} \tag{6}$$

subject to its budget constraint:

$$\begin{aligned} & E_t \sum_{i=0}^{\infty} \beta^i \left(C_{t+i} + \frac{R_{t+i}^{-1} B_{t+i} + M_{t+i}}{P_{t+i}} \right) \\ = \; & E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{W_t(ho)}{P_{t+i}} N_{t+i}(ho) + \frac{T_{t+i}}{P_{t+i}} + \frac{\Pi_{t+i}}{P_{t+i}} + \frac{B_{t+i-1}}{P_{t+i}} + \frac{M_{t+i-1}}{P_{t+i}} \right] \end{aligned} \tag{7}$$

where P_t is the aggregate price index, $R_{t+i} = 1 + r_{t+i}$ is the discount factor on its one-period bond holdings B_{t+i}, T_{t+i} is its net lump-sum transfers from

[46] As usual in the literature, we assume complete insurance markets that allow households to share the income risk stemming from staggered wage setting.

[47] We choose a separable utility function with the standard desirable long-run properties.

government, and Π_{t+i} is its profit income, which is transferred to consumers in lump sum manner.

The household's decision can be decomposed into two optimization problems. First, the "wage contracting problem" which only takes place with probability $(1-\theta_w)$ in each period. Here the utility function is maximized with respect to the optimal wage. Second, the "intra-contract problem" in which the contract wage is given and the household maximizes its utility with respect to its other endogenous variables (consumption, money and bond holdings) each period.

Solving the wage contracting problem, we obtain the following optimal wage[48]:

$$w_t^*(ho) = \mu_w + (1-\beta\theta_w)E_t\sum_{i=0}^{\infty}(\beta\theta_w)^i\left(\ln\left[-\frac{Ut_N(N_{t+i}(ho))}{Ut_C\left(C_{t+i}\right)}\right]+p_{t+i}\right) \quad (8)$$

where $w_t^*(ho)$ is the logarithm of the re-set wage and $\mu_w = (\varepsilon_w/(\varepsilon_w-1))$ is the steady state mark-up over the marginal rate of substitution and Ut_N, Ut_c are the first derivatives of the utility function with respect to labor and consumption. And $-Ut_N(N_{t+i}(ho))/Ut_c\left(C_{t+i}\right)$ denotes the marginal rate of substitution between labor and consumption.

For the intra-contract problem we obtain the following general first order conditions:

$$Ut_{C_t} = \beta R_t E_t\left(Ut_{C_{t+1}}\frac{P_t}{P_{t+1}}\right) \quad (9)$$

and

$$\frac{Ut_{M_t}}{Ut_{C_t}} = 1 - R_t^{-1} \quad (10)$$

where Ut_{C_t}, Ut_{M_t} denote the first derivatives of the utility function with respect to consumption and money holdings in period t.

Log-linearizing the consumption function and money demand function derived from the household's decision problem, we obtain:

$$c_t = E_t(c_{t+1}) - \frac{1}{\sigma}(r_t - E_t(\pi_{t+1}) - \ln\beta) \quad (11)$$

and

[48] The derivations of these and further results are given in the Technical Appendix.

$$\tilde{m}_t - \tilde{p}_t = \frac{\sigma}{\nu}\tilde{c}_t - \iota \tilde{r}_t \tag{12}$$

where $\iota = (1/\bar{r}\nu)$ and[49] $\bar{r}$ is the steady state interest rate.

Finally, we close the system with a goods market clearing condition (13), a production function (14) and a money supply equation (15):

$$y_t = c_t \tag{13}$$

$$y_t = a_t + (1-\alpha)\, n_t \tag{14}$$

$$m_t = m_{t-1} + \Delta m_t. \tag{15}$$

Dynamic System: For the wage staggering model, the intertemporal output response to the monetary shock can be derived from equations (2), (8), (11), (12), (13), (14) and (15), yielding

$$\begin{aligned} & E_t\left(\left[1 + \frac{1}{\sigma}\frac{\alpha}{1-\alpha}\right] \tilde{y}_{t+1}\right) + \frac{1}{\sigma} E_t\left(\tilde{w}_{t+1}\right) + \frac{1}{\sigma\iota}\left(\tilde{m}_t - \tilde{p}_t\right) \\ = \; & \left(1 + \frac{1}{\sigma\iota} + \frac{1}{\sigma}\frac{\alpha}{1-\alpha}\right)\tilde{y}_t + \frac{1}{\sigma}\tilde{w}_t \end{aligned} \tag{16}$$

$$\begin{aligned} \beta\theta_w E_t \tilde{w}_{t+1} = \; & \left[(1+\beta)\,\theta_w\right] \tilde{w}_t - \theta_w w_{t-1} \\ & - \frac{1}{1+\varphi\epsilon_w}(1-\theta_w)(1-\beta\theta_w)\left[\sigma + \frac{\varphi+\alpha}{(1-\alpha)}\right]\tilde{y}_t \end{aligned} \tag{17}$$

where $(\tilde{m}_t - \tilde{p}_t)$ are the real money balances. The first equation expresses an IS type relation between the deviations of real money holdings, wages and output from the steady state. The second equation expresses the wage dynamics in dependence of the output deviations.[50]

[49] When we have a one-off monetary shock, the interest elasticity is not of further relevance for the IRFs of the dynamic system. For the calculations below, we assumed $\sigma = \nu = 1$.

[50] The wage can also be expressed in terms of prices, by using the relationship from the production function (1): $\tilde{w}_t = \tilde{p}_t - (\alpha/(1-\alpha))\, \tilde{y}_t$. Thus the two equations can be re-written in terms of prices instead of wages. Further note that equation (15) holds.

3.2.2 Price Staggering

The labor market is perfectly competitive; labor is a homogeneous factor; households and firms are wage-takers. There is a continuum of goods and a fixed number of identical households (normalized to unity). Each household maximizes its utility with respect to consumption of all the goods, labor, and real money balances, subject to its budget constraint.

Firms: Minimizing the cost of consumption of the different product varieties for a given consumption bundle,

$$Y_t = \left[\int_{j'=0}^{1} Y_t \left(j'\right)^{\frac{\varepsilon_p - 1}{\varepsilon_p}} dj' \right]^{\frac{\varepsilon_p}{\varepsilon_p - 1}} \tag{18}$$

we obtain the following product demand function:

$$Y_{t+i} \left(j\right) = \left(\frac{P_t^* \left(j\right)}{P_{t+i}} \right)^{-\varepsilon_p} Y_{t+i} \tag{19}$$

where $P_t^* \left(j\right)$ is the wage set by firm j. The corresponding aggregate price index is P_{t+i} is defined as

$$P_{t+i} = \left[\int_{j'=0}^{1} P_{t+i} \left(j'\right)^{1-\varepsilon_p} dj' \right]^{\frac{1}{1-\varepsilon_p}}. \tag{20}$$

In each period the firm resets its price with probability $(1 - \theta_p)$. Thus the firm maximizes its profit

$$\max_{\{P_t^*(j)\}} E_t \sum_{i=0}^{\infty} \left(\beta\theta_p\right)^i \left(P_t(j)\, Y_t(j) - N_t(j)\, W_t\right) \tag{21}$$

subject to its production function

$$Y_t(j) = A_t N_t(j)^{1-\alpha} \tag{22}$$

and to its product demand function (19).

Solving this problem we obtain the following price setting equation:

$$p_t^* = \mu_p + (1 - \beta\theta_p) E_t \sum_{i=0}^{\infty} \left(\beta\theta_p\right)^i mc_{t,t+i}^{no} \tag{23}$$

where $\mu_p = \left(\varepsilon_p / \left(\varepsilon_p - 1\right)\right)$ is the steady state mark-up over marginal costs and

$mc^{no}_{t,t+i}$ are the nominal marginal costs in period $t+i$ when prices were set in period t.

Households: As households are wage takers in the price-staggering model, their optimality problem reduces to the intra-contract optimization problem of the wage staggering model above, with the difference that they optimize with respect to their labor supply and all other endogenous variables:

$$\begin{aligned}
&\max_{\{C_{t+i},B_{t+i},M_{t+i},N_{t+i}\}} E_t \sum_{i=0}^{\infty} \beta^i \left[Ut \left(C_{t+i}(ho), \frac{M_{t+i}(ho)}{P_{t+i}}, N_{t+i}(ho) \right) \right] \\
= &\left[E_t \sum_{i=0}^{\infty} \beta^i \left(\frac{C_{t+i}^{1-\sigma}(ho)}{1-\sigma} + \frac{\left(\frac{M_{t+i}(ho)}{P_{t+i}} \right)^{1-\nu}}{1-\nu} - \frac{N_{t+i}^{1+\varphi}(ho)}{1+\varphi} \right) \right] \qquad (24)
\end{aligned}$$

subject to its budget constraint

$$\begin{aligned}
&E_t \sum_{i=0}^{\infty} \beta^i \left(C_{t+i} + \frac{R_t^{-1} B_{t+i} + M_{t+i}}{P_{t+i}} \right) \qquad (25) \\
= \; &E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{W_t(ho)}{P_{t+i}} N_{t+i} + \frac{T_{t+i}}{P_{t+i}} + \frac{\Pi_{t+i}}{P_{t+i}} + \frac{B_{t+i-1}}{P_{t+i}} + \frac{M_{t+i-1}}{P_{t+i}} \right]
\end{aligned}$$

This yields the following labor supply function (in logs), in addition to (11) and (12):

$$w_t - p_t = \sigma c_t + \varphi n_t. \qquad (26)$$

Dynamic System: In the price-staggering model, the associated intertemporal output response to the monetary shock is described by the following two equations, which can be derived from (1), (11), (12), (23), (26), (13), (14) and (15), yielding:

$$E_t \tilde{y}_{t+1} + \frac{1}{\sigma} E_t \tilde{p}_{t+1} + \frac{1}{\sigma\iota} (\tilde{m}_t - \tilde{p}_t) = \left(1 + \frac{1}{\sigma\iota} \right) \tilde{y}_t + \frac{1}{\sigma} \tilde{p}_t \qquad (27)$$

$$\beta E_t \tilde{p}_{t+1} = (1+\beta) \tilde{p}_t - \tilde{p}_{t-1} - \kappa \tilde{y}_t \qquad (28)$$

where $\kappa = \left(\sigma + \frac{\varphi+\alpha}{1-\alpha} \right) [(1-\theta_p)(1-\beta\theta_p)(1-\alpha)] / [\theta_p [1 + \alpha(\varepsilon_p - 1)]]$. Furthermore equation (15) holds.

$\theta_w = 0.75$	$\theta_p = 0.75$	$\alpha = 0.3$
$\varphi = 1$	$\nu = 1$	$\sigma = 1$
$\beta = 0.99$	$\varepsilon_w = 10$	$\varepsilon_p = 10$

Table 1: Calibration values

3.3 The Effect of Competition on Monetary Persistence

We consider monetary persistence in response to a simple, one-off money growth shock. In particular, suppose that money growth is initially zero, then in period 1 it increases to some positive constant (normalized to unity), and thereafter it returns to zero. By "monetary persistence" we mean the effects of this shock on output *after* period 1 (i.e. from period 2 onwards).

3.3.1 The Conventional Case

We simulate the impulse response functions (IRFs) of the deviation of output from the steady state under wage and price staggering with respect to a one-off 1% money growth shock,[51] for the standard parameter values[52], as described in table (1).

The values for θ_w and θ_p imply that prices or wages are set every four quarters, on average.[53] Since there are diminishing returns to labor in the short run (over which the monetary shocks work themselves out), we set $\alpha = 0.3$, which is the standard value (corresponding to a 70% labor share of income under perfect competition). By setting $\sigma = 1$, we obtain a logarithmic utility function for consumption. Furthermore, we choose $\nu = 1$. The disutility of labor is quadratic ($\varphi = 1$). By setting $\beta = 0.99$, we obtain a quarterly real discount rate of 1%, i.e. about 4% a year, as it is standard in the literature.

The value for ε_p implies a steady state mark-up of about 11% over marginal costs, whereas the interpretation for ε_w is somewhat more difficult, it is the mark-up over marginal rate of substitution between work and consumption.[54] For the moment we assume that $\varepsilon_w = \varepsilon_p$ and set them both to 10, as it is common in the literature (see e.g. Kim, 2003), although there is no empirical literature that would give explicit support for this assumption.

[51] The nominal money supply increases by one percent in period 1.

[52] In addition, the elasticity of substitution at the labor market is varied, which is discussed later.

[53] This is in line with the empirical evidence surveyed by Taylor (1999). In a very recent study Stahl (2005) shows that an average price duration of one year, before a new increase takes place, is a fairly consistent pattern for the German metal working industry.

[54] For a discussion of the role of the marginal rate of substitution, see e.g. Gali et al. (2003).

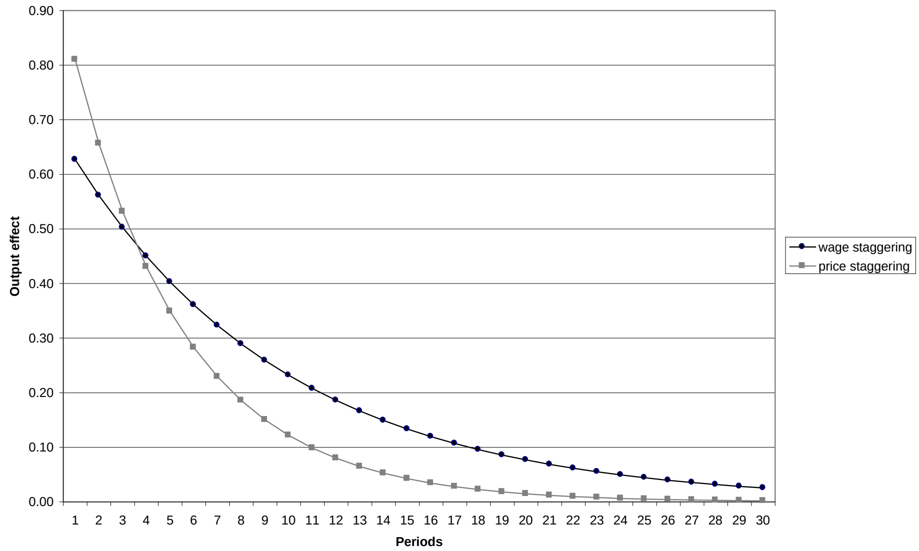


Figure 1: The conventional case

Under this standard assumption, we obtain the conventional finding of the existing literature, namely that the output response dies out more slowly under wage staggering than under price staggering. Existing studies in general use the contract multiplier to measure persistence (see e.g. Huang and Liu, 2002),[55] dividing the output effect in the fourth period (as the average contract duration is 4 when setting either θ_w or θ_p to 0.75) by the output effect during the impact period. For the described calibration we get a contract multiplier of 53% for price staggering, whereas it is 72% for wage staggering (see figure (1) for an optical inspection).

3.3.2 Competition and Persistence

Numerical Results: For simplicity, we capture the degree of competition in the product and labor markets by the elasticities of substitution among products (in household consumption) and among labor types (in firm production), respectively. The greater the product elasticity of substitution, the lower is the mark-up of prices over marginal cost (Lerner's index of monopoly power); the greater the labor elasticity of substitution, the lower is the mark-up of wages over the marginal rate of substitution between labor and consumption.

For a variety of reasons, product markets are commonly more competitive

[55] Chari et al. (2000, p. 1152) use a somewhat different version of the contract multiplier, defined as: "half life of output in the model with staggered price setting to the half life of output under synchronized price setting."

than labor markets. This is certainly true under centralized wage bargaining, since centralized price bargaining is relatively uncommon. But even in the absence of centralized wage bargaining, wage setting often tends to be more centralized than price setting: workers of comparable types in an enterprise or firm often set their wages at the same time, whereas such synchronization generally does not apply to substitutable products across the economy. Consequently, firms' costs of switching among standard labor types tends to be substantially greater than consumers' costs of switching among standard product types.

Microeconomic evidence shows that the elasticities of substitution among different labor types are quite low. Griffin's (1992)[56] estimate for the elasticity of substitution between white males and females as well as for white males and black males are e.g. roughly 3.[57] Thus we set the elasticity of substitution to 2 and 4, respectively.[58] The elasticities of substitution that are used for different product types in the literature have a very wide span too. We are aware of a range from 6 (Sbodorne, 2002) to 10 (Chari et al., 2000) or 11 (Galì, 2003), which would mean mark-ups between 10 and 20% over the marginal costs.

It turns out that the relative degrees of competition in the product and labor markets (viz., the relative elasticities of substitution[59]) play an important role in determining the relative magnitudes of monetary persistence generated by wage and price staggering. To show this, we plotted the output responses for different labor elasticities of substitution ($\varepsilon_w = 2$, $\varepsilon_w = 4$) that may be empirically more realistic (see figure (2)).

The impulse response function of the price-staggering model ($\varepsilon_p = 10$) starts at a much higher level than the one for the wage staggering function. It dies out at about the same speed than the one of the wage staggering model with $\varepsilon_w = 2$ and somewhat faster as the one with $\varepsilon_w = 4$.

[56] Griffin (1992) used firm-level data for 555 large firms listed on the New York Stock Exchange.

[57] Based on an estimation with a translog cost system with capital included and with federal contractors. See Griffin (1992).

[58] We are in line with Huang and Liu (2002), who - in contrast to many other authors - use different values for the elasticities of substitution of wage and price staggering. They set ε_w equal to 2, 4 and 6 alternatively.

[59] In the context of our model, the elasticity of substitution among labor types depends on what constitutes a wage-setting cohort. If workers with comparable human capital set their wages at the same time, then the corresponding elasticity of substitution among different cohorts will be relatively small. On the other hand, if wage-setting cohorts are chosen randomly across occupations, then the corresponding elasticity will of course be relatively high.

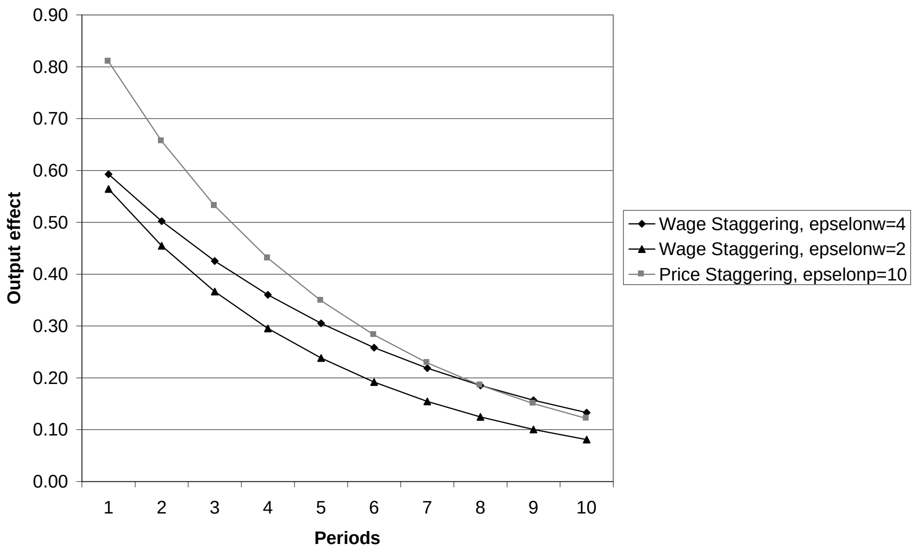


Figure 2: Output IRFs for different market structures

An Alternative Measure of Monetary Persistence: When we set $\varepsilon_p = 10$ and $\varepsilon_w = 4$, the contract multiplier for wage staggering is 61% and thus well above the 53% for price staggering. Again, even with a significant difference in the market structure in the product and labor market, the conventional wisdom seems to hold: wage staggering generates more output persistence than price staggering in terms of the contract multiplier. Nevertheless, the optical inspection of figure (2) calls this result into question. Although the output IRF for wage staggering dies out more slowly (see contract multiplier), it starts at a much lower level. The contract multiplier captures the relative change in the slope of the IRFs, but not the relative positions of these IRFs. If the wage and price staggering IRFs had the same slope, but the wage setting IRF were much lower, then the wage and price-setting responses would have the same contract multiplier, but we would clearly like to say that the output response under price setting is more persistent (in some sense) than that under wage setting.

On this account, we propose a new output persistence measure. Our main measure of monetary persistence will be what we have called *quantitative persistence*: the sum of all output changes from period 2 onwards, due to a one-off monetary shock which is normalized to a unit shock:

$$\psi = \sum_{t=2}^{\infty} \tilde{y}_t \tag{29}$$

where $\tilde{y}_t$ is the difference between output in the presence and absence of the shock (deviations from the steady state).

This expression would have to be rewritten if we assume an exogenous serial correlation of the money supply, as it is done in most chapters. Then we would have to subtract the effects, resulting from the additional increase in the money supply due to the serial correlation.

When $\varepsilon_p = \varepsilon_w = 10$, then the quantitative persistence measure is 5.37 for wage staggering and 3.46 for price staggering. Thus the qualitative result of the "contract multiplier" that wage staggering is more persistent than price staggering is confirmed when both markets have the same competitive structure.

For $\varepsilon_p = 10$ and $\varepsilon_w = 4$, the quantitative persistence measure is 3.46 for price staggering and 3.28 for wage staggering. Thus the degree of persistence is similar, albeit somewhat bigger for price staggering. This result is more in line with the optical inspection of figure (2), which shows two impulse response functions with a similar output effect. As a consequence, the conventional result that wage staggering is always a lot more persistent than wage staggering is already questioned.

For $\varepsilon_w = 2$ the contract multiplier drops to 52%. Thus it indicates equivalence of wage and price staggering. The visual inspection of figure (2) shows that the contract multiplier tells a completely counter-intuitive story. Both IRFs die out at about the same speed,[60] but the IRF for price staggering starts at a much higher level. From our point of view it would be hard to claim that the two IRFs are equivalent in terms of output persistence. The quantitative persistence captures the difference appropriately and falls to 2.34 for $\varepsilon_w = 2$, whereas it is 3.46 for price staggering. As a consequence, the quantitative persistence measure signals that price staggering is almost 50% more persistent than wage staggering.

Figure (3) depicts the persistence from price staggering to wage staggering (as a quotient, in terms of quantitative persistence) when we fix $\varepsilon_p = 10$ and change the labor elasticity of substitution (ε_w) in the wage staggering model (the labor elasticity of substitution varies from 1 to 10, corresponding to a range of $\varepsilon_p - \varepsilon_w$ from -9 to 0, as shown in figure (3)). It can be seen that the labor elasticity of substitution (ε_w) has to be about 5.5 units smaller than the product elasticity of substitution (ε_p) to obtain the same "quantitative persistence" for both staggering types (quotient is equal to 1). The more

[60] As measured by the contract multiplier.

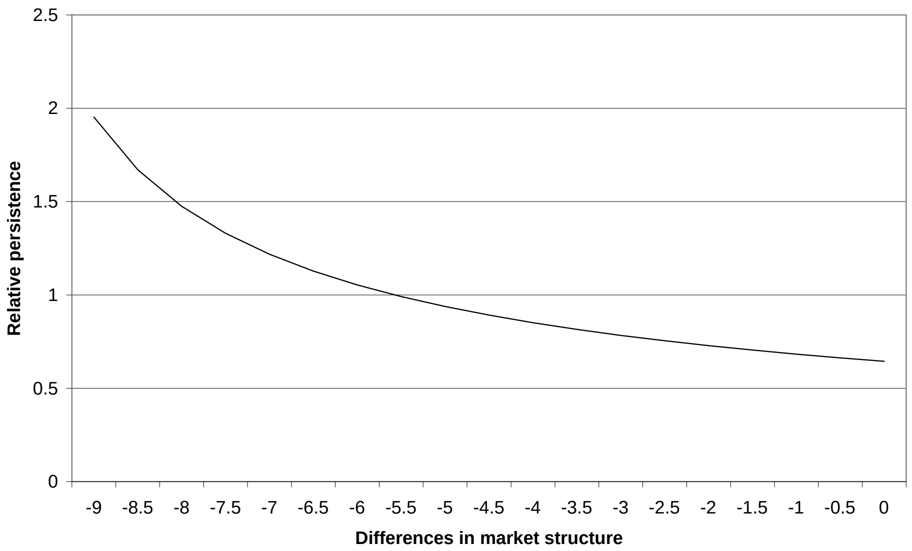


Figure 3: Competition and relative persistence (the elasticity of substituion for different product types is fixed to 10. The abscissa denotes $\varepsilon_p - \varepsilon_w$.)

competitive the product market is relative to the labor market, the greater is the persistence from price staggering relative to wage staggering.

The gap between ε_w and ε_p that is necessary to generate the same output persistence by wage and price staggering depends of course on the base value for ε_p. The smaller ε_p, the smaller has to be the gap to obtain the same quantitative persistence. If we assume for example that the elasticity of substitution in the product market is 6, which appears to be the lower bound in the literature, then the two models would show the same persistence if the elasticity of substitution in the labor market would be 2.5.[61]

3.3.3 Intuition

The Conventional Intuition: The conventional intuition on why monetary persistence is greater under wage staggering than under price staggering may be summarized as follows.[62] Suppose that there are constant returns to labor. Under *price staggering* households set their wages as mark-up over the current marginal rate of substitution.[63] As the households' wage decision is synchronized, wages adjust quickly. They even overshoot their new steady

[61] In both cases the quantitative persistence measure would be about 2.6.

[62] See Huang and Liu (2002) for a more detailed description.

[63] Under perfect competition, naturally, wages are equal to the marginal rate of substitution.

state level, since the positive output effect during the initial periods after the shock increases the marginal disutility of labor and thus raises the marginal rate of substitution between work and consumption. In response, firms raise their prices quickly, since these prices are a constant mark-up over current and future marginal costs (due to constant returns to labor). However prices adjust less quickly than they would do in the absence of price staggering.

Under *wage staggering,* a positive monetary shock raises employment and, with it, the disutility of labor, and thus each household has an incentive to push the wage up. But an increase in the individual wage also raises the household's wage relative to other wage setting cohorts, leading to a fall in the demand for the household's labor. These wage adjustments are moderate, however, since households dislike fluctuations in their working hours (as the marginal disutility of labor rises with hours employed).

Thus, in contrast to the price-staggering model, there is a gradual rise in wages, rather than overshooting. This leads to slower price adjustments by firms,[64] even though prices can be adjusted instantaneously. The slower price adjustment leaves more room for output deviations from the steady state.

Consequently wage staggering delivers more output persistence than does price staggering.

Intuition on How Diminishing Returns Affect Monetary Persistence: We have argued that monetary persistence is a short-run phenomenon, over which returns to labor are generally diminishing. In this context, marginal costs are clearly no longer constant across firms, but depend on the firms' employment.[65]

When there is a positive monetary shock in the *price-staggering model*, then (as above) households adjust their wages upwards instantaneously and wages overshoot their long-run equilibrium. This leads to a rise in average marginal costs for the economy. Thus each firm has an incentive to raise its price. When it does, its price rises relative to other prices and its marginal costs rise relative to other marginal costs.[66] Due to these variations in firm-specific marginal costs, the firm's price increase will be less than it would have

[64]When we assume no productivity shocks the deviations of the marginal costs from the steady state would be equal to the deviations of the wages from the steady state $\tilde{m}c_t = \tilde{w}_t$. The firm sets prices equal to marginal costs ($\tilde{p}_t = \tilde{m}c_t$).

[65]Mathematically: $\tilde{p}_t = \tilde{m}c_t = \tilde{w}_t + (\alpha/(1-\alpha))\,\tilde{y}_t$.

[66]In mathematical terms: $\tilde{m}c^r_{t,t+i} = \tilde{m}c^r_{t+i} - (\varepsilon_p \alpha/(1-\alpha))\left(p^*_t - \tilde{p}_{t+i}\right)$, where $\tilde{m}c^n_{t,t+i}$ is the deviation of the firm-specific nominal marginal costs from the steady state and $\tilde{m}c^n_{t+i}$ is the one of the average economy wide average nominal marginal costs.

been if all firms had the same marginal cost schedule under constant returns to labor. (The faster the returns to labor diminish, the more moderate the price adjustment will be.) Thus the adjustment path from the old to the new steady takes a longer time.[67] This extends the duration of the deviation of output from the steady state, i.e. it magnifies output persistence.[68]

Under *wage staggering*, decreasing returns to labor lead to larger deviations of prices from the old steady state in the impact period than constant returns. The reason is that prices are a mark-up over marginal costs, the marginal costs depend on the deviation of output from the steady state (under diminishing returns), and output responds to the monetary shock.[69] Because of the instantaneous inflation jump during the impact period (see figure (4)), the room for output adjustments will be reduced considerably and thus the wage staggering mechanism will generate less persistence in terms of "quantitative persistence" than under constant returns to labor.

Although the New Keynesian literature often claims that wage staggering generates more plausible impulse response functions of output with respect to monetary shocks, our analysis sounds a cautionary note. First, as noted, the wage staggering generates more output persistence only when the elasticities of substitution for labor and products are sufficiently close. Secondly, wage staggering has a lower inflation persistence than price staggering, either in terms of the contract multiplier or in terms of quantitative persistence (see figure (4)).

The intuition above shows why the existing literature - resting on the assumption of constant returns to labor - concludes that wage staggering generates more output persistence than price staggering. If the marginal disutility of labor function is assumed to be increasing with output, whereas the marginal cost curve is assumed to be flat and thus independent of the firm-specific output, then wage staggering turns out to lead to more output persistence than price staggering. But in the presence of diminishing returns to labor - which is appropriate in the context of monetary persistence - the output effects of

[67] Mathematically this can be seen in the following Phillips curve relationship, by setting α to different values $\beta E_t \tilde{\pi}_{t+1} = \tilde{\pi}_t - [(1-\theta_p)(1-\beta\theta_p)(1-\alpha)] / [\theta_p [1+\alpha(\varepsilon_p - 1)]] \tilde{y}_t$.

[68] Note that there is a second countervailing effect. Under decreasing returns to labor the average marginal costs in the economy rise steeper when there is a positive output effect. As a consequence, the overall output effect in the economy is reduced, as we have even more pro-cyclical average marginal costs than under constant returns to labor. Nevertheless, this second effect is dominated by the first one under usual calibrations.

[69] Mathematically, $\tilde{p}_t = \tilde{w}_t + (\alpha / (1-\alpha)) \tilde{y}_t$. When $\alpha = 0$ (constant returns to labor), we obtain $\tilde{p}_t = \tilde{w}_t$.

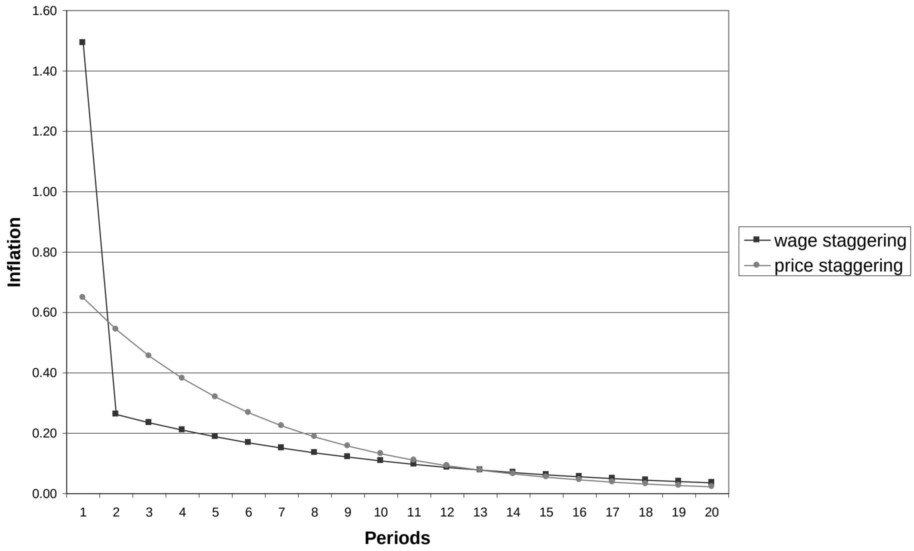


Figure 4: Inflation persistence

the wage staggering mechanism are weakened and thus the conventional result need no longer hold.

Intuition on How Competitiveness Affects Monetary Persistence: We now explain intuitively how the relative competitiveness of the labor and product markets influences monetary persistence. We measure relative competitiveness in terms of the relative elasticities of substitution among products and labor types. The greater the elasticity of substitution, the smaller is the individual wage rise (in the wage staggering model) or price rise (in the price-staggering model) relative to the market average, in response to a positive monetary shock. Since demand fluctuations are undesirable for households and firms with respect to their utility and profit maximization, the degree of wage/price adjustment will be more muted.[70] As result, the output response is more persistent.

This means that relative competitiveness matters for persistence. The more competitive the product market relative to the labor market, the greater is the monetary persistence generated by price staggering relative to that generated by wage staggering.

[70] Firms face the following demand schedule $Y_{t+i}(j) = \left(P_t^*(j) / P_{t+i}\right)^{-\varepsilon_p} Y_{t+i}$ and the labor demand looks as follows $N_{t+i}(ho) = \left(W_t^*(ho) / W_{t+i}\right)^{-\varepsilon_w} N_{t+i}$.

3.4 Complementarities between Wage and Price Staggering

Finally, consider an economy where households and firms set *both* prices and wages in a staggered fashion. Specifically, households set their wages as mark-up over the current and future individual marginal rate of substitution and prices, firms set their prices as mark-up over their current and future firm-specific marginal costs. Consequently, there is an *intertemporal wage-price spiral:* the slower wages adjust, the slower prices adjust, and vice versa.

The dynamic system for joint wage and price staggering is

$$E_t\tilde{y}_{t+1}+\frac{1}{\sigma}E_t\tilde{p}_{t+1}+\frac{1}{\sigma\iota}\left(\tilde{m}_t-\tilde{p}_t\right)=\left(1+\frac{1}{\sigma\iota}\right)\tilde{y}_t+\frac{1}{\sigma}\tilde{p}_t \tag{30}$$

$$\beta E_t\tilde{p}_{t+1}=\left(1+\beta+\delta\right)\tilde{p}_t-\tilde{p}_{t-1}-\delta\tilde{w}_t^{no}+\delta\frac{\alpha}{1-\alpha}\tilde{y}_t \tag{31}$$

$$\beta\theta_w E_t\tilde{w}_{t+1} = -\theta_w\tilde{w}_{t-1}+(1+\beta\theta_w^2-\frac{1}{1+\varphi\epsilon_w}(1-\theta_w)(1-\beta\theta_w)\varphi\epsilon_w)\tilde{w}_t \tag{32}$$

$$-\frac{1}{1+\varphi\epsilon_w}(1-\theta_w)(1-\beta\theta_w)((\sigma+\varphi\frac{1}{(1-\alpha)})\tilde{y}_t+\tilde{p}_t) \tag{33}$$

and the money growth equation (15) holds.

In this context, we inquire whether wage and price staggering are complementary in their influence on monetary persistence, i.e. whether their joint effect on persistence is greater than the sum of the individual effects. Specifically, we measure the degree of complementarity (υ_{com}) by dividing the joint effect of wage and price staggering (ψ_{w+p}) by the sum of individual effects of the two types of staggering ($\psi_p+\psi_w$):

$$\upsilon_{com}=\frac{\psi_{w+p}}{\psi_p+\psi_w}. \tag{34}$$

Values bigger than 1 signal that wage and price staggering are complementary, whereas they are substitutes for values smaller than 1.

When we set $\varepsilon_p=10$ and $\varepsilon_w=4$ (and use the same calibration as before, figure (5) shows the impulse response functions of the three models), we get a quantitative persistence measure of 7.75 for joint staggering, which gives us a complementarity measure of $\upsilon_{com}=1.15$. Thus joint wage and price

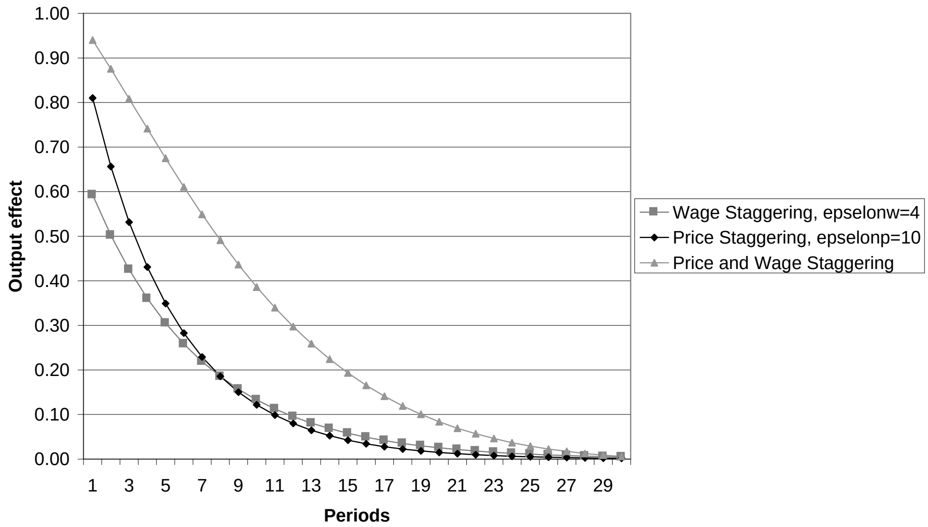


Figure 5: IRFs from wage staggering, price staggering and both types

staggering is 15% more output persistent than the sum of the two staggering mechanisms.[71]

It can be shown that the complementarity depends on the existence of decreasing returns to labor. In our numerical simulations, wage and price staggering are not complementary under constant returns to labor, and they become complementary only once α is larger than 0.15 (see figure (6)).

3.5 Relation to the Literature

There is a relatively large body of literature on the relative degree of monetary persistence arising from wage and price staggering under Taylor contracts, but relatively little under Calvo contracts (the focus of this chapter).

As noted, the recent literature on Taylor contracts concludes that wage staggering generates more monetary persistence than price staggering. In Andersen's (1998) model output responses from wage staggering are always longer lived than from price staggering. In Huang and Liu's (2002) paper the output responses from price staggering are dampened oscillatory, whereas the output IRFs from wage staggering are not.[72] The oscillatory output response to monetary shocks under the standard numerical calibrations in dynamic stochastic

[71] As the contract multiplier is 53% for price staggering and 61% for wage staggering, it would be impossible to have complementarities.

[72] Erceg (1997) uses both types of staggering, which can account for a strong contract multiplier.

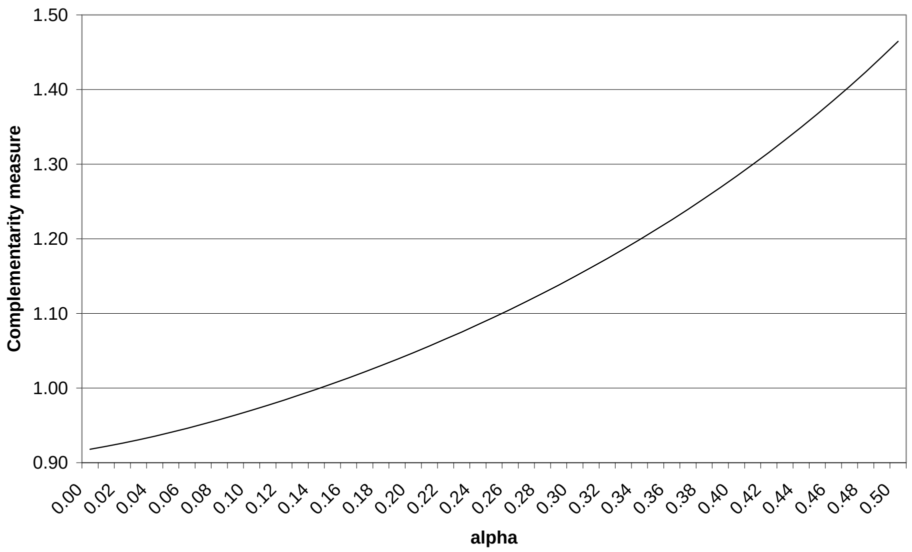


Figure 6: Complementarities between wage and price staggering

general equilibrium (DSGE) models (Kiley, 1997, Chari et al., 2000, Huang and Liu, 2002) is considered an important weakness of the Taylor model.

Some authors have sought to overcome persistence problems by incorporating real rigidities in price-staggering models. Edge (2002) assumes firm-specific factor inputs to restore the equivalence of wage and price staggering, i.e. that each household is coupled with a firm, hiring its labor and capital out to that firm only.[73] Jeanne (1998) introduces a real wage rigidity, as unions may be concerned about a fair division of income between labor and capital. Kiley (1997) analyzes the effect of several real rigidities to increase the persistence of price staggering, such as countercyclical mark-ups.[74] The basic insight goes back to Blanchard and Fischer (1989) and Ball and Romer (1990), who argue that it is necessary to flatten the supply side in order to prevent procyclical marginal costs, which would lead to fast price adjustments and thus low persistence.

Taylor (1999) observed that "there needs to be some neighborhood effects between price setters, so that one firm pays attention to the price decision of the next firm and the most recent firm, thereby linking the price decision of one firm to another and causing the persistence effects". This phenomenon applies to our price-staggering model. Under decreasing returns to labor, firms

[73] The basic idea to slow down price adjustments with real rigidities in a DSGE model with nominal rigidities was first proposed by Kimball (1995) and implemented by Rotemberg (1996). In a unifying framework Ascari (2003) shows that labor immobility plays a key role in generating persistence.

[74] Kiley (1997) therefore used the ideas of a model from Gali (1994).

pay more attention to their relative price from a purely profit-maximizing perspective. If the firm specific price is too far above the average market price,[75] there will be undesirable fluctuations in firm-specific demand.[76]

Regarding Calvo contracts (as in this chapter), various contributions examine how realistically Calvo wage and/or price staggering can replicate empirical impulse response functions or how optimal monetary policy has to be conducted in such a framework.[77] To the best of our knowledge, however, the only study that explicitly discusses the differences in persistence generated by Calvo wage and price staggering is Kim (2003). He states that in contrast to Taylor contracts, Calvo wage and price staggering can both generate persistence (no oscillatory movements). But similar to the studies for Taylor staggering, he concludes that wage staggering is generally better able to generate persistence. We confirm the first result, but have doubts about the second because it hinges on two important implausible assumptions: (i) in the basic version of Kim's model (section 2.2.1) the capital stock adjusts flexibly and instantaneously (which we have argued is unlikely to occur over the time span relevant for monetary persistence)[78] and (ii) Kim (2003) assumes the same elasticity of substitution for different product and labor types, whereas we argue that product markets are generally more competitive than labor markets.

The inability to explain sufficient inflation persistence is known to be a major weakness of New Keynesian models (see, for example, Mankiw, 2001). This chapter contributes to this literature by showing and explaining the intuition why wage staggering under decreasing returns has a low inflation persistence, either measured in terms of the contract multiplier or in terms of "quantitative persistence."

The role of the elasticity of substitution has been mentioned in the lit-

[75] See Sbodorne (2002) for an equivalent mathematical derivation.

[76] Thus our result is somewhat contrasting to Kiley's (1997), who claims that increasing returns to labor flatten marginal costs and thus increase persistence. The effect we describe above cannot kick in, as Kiley (1997) uses a first order Taylor approximation to remove firm-specific subscripts. Further differences are that his model incorporates capital accumulation and uses Taylor contracts.

[77] To mention just a few examples: Rotemberg and Woodford (1998) try to match empirical impulse response functions with a Calvo price staggering model. Christiano et al. (2005) have the same objective. Gali (2003) derives impulse response functions from Calvo price staggering and discusses optimal monetary policy. Erceg et al. (2000) use a model with Calvo wage and price staggering that is similar in spirit to ours. They do not discuss the issue of monetary persistence, but optimal monetary policy.

[78] Eichenbaum and Fisher (2004) find out that a fixed-capital version fits the empirical evidence better. A discussion of this issue can be found in Altig et al. (2005). This and other very recent papers (e.g. Woodford, 2005) model firm-specific capital endogenously.

erature (Ascari, 2003, Huang and Liu, 2002[79]), but the influence of *relative competitiveness* in the labor and product markets on the relative monetary persistence generated by wage and price staggering has not been analyzed. This chapter does so numerically and intuitively. Furthermore, the existing literature uses the contract multiplier to measure output persistence from numerical impulse response functions (see e.g. Huang and Liu, 2002, Kim 2003). The weaknesses of this measure have not been discussed to date. This chapter does so and introduces the quantitative persistence measure to address this problem. The complementarity of wage and price staggering in generating persistence has not been examined either in the literature; our "quantitative persistence" measure enables us to do so in a meaningful way.

3.6 Concluding Thoughts

This chapter shows that the relative degree of competition in the labor and product markets plays a central role in determining the relative monetary persistence arising from wage and price staggering. The more competitive a market is, the more persistent will be the output responses to a monetary shock arising from the wage or price inertia in that market. The intuition is that deviating too much from the optimal price or wage will lead to bigger demand changes in the labor or product markets if there is more competition (i.e. the elasticity of substitution is bigger). Consequently, more competition leads to a dampened wage and price adjustment, which leaves more room for deviations of the output from the steady state.

Finally, we find that wage and price staggering have complementary effects on monetary persistence. We show this in terms of a new measure of monetary persistence, our "quantitative persistence" statistic. The existence of complementarities means that beyond understanding how wage and price staggering work in isolation, it is very important to explore their interactions.

[79] Both studies use Taylor contracts.

3.7 Technical Appendix

3.7.1 Wage Staggering Model

Household's Optimization Problem: The representative household optimizes the following utility function:

$$\max_{\left\{C_{t+i},W_t(ho),B_{t+i},M_{t+i}\right\}} E_t \sum_{i=0}^{\infty} \beta^i \left[\begin{array}{c} Ut\left(C_{t+i}\left(ho\right)\right) - \\ Ut\left(N_{t+i}\left(ho\right)\right) + Ut\left(\frac{M_{t+i}(ho)}{P_{t+i}}\right) \end{array} \right] \tag{35}$$

subject to its budget constraint:

$$\begin{aligned} & E_t \sum_{i=0}^{\infty} \beta^i \left(C_{t+i} + \frac{R_{t+i}^{-1} B_{t+i} + M_{t+i}}{P_{t+i}} \right) \\ = \; & E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{W_t\left(ho\right)}{P_{t+i}} N_{t+i}\left(ho\right) + \frac{T_{t+i}}{P_{t+i}} + \frac{\Pi_{t+i}}{P_{t+i}} + \frac{B_{t+i-1}}{P_{t+i}} + \frac{M_{t+i-1}}{P_{t+i}} \right] \end{aligned} \tag{36}$$

and its labor demand function:

$$N_{t+i}\left(ho\right) = \left(\frac{W_t^*\left(ho\right)}{W_{t+i}} \right)^{-\varepsilon_w} N_{t+i}, \; i = 1, ..., N-1 \tag{37}$$

where P_t is the aggregate price index, R_{t+i}=1 + r_{t+i} is the nominal interest factor on its bond holdings B_{t+i}, T_{t+i} is its net lump-sum transfers from government, and Π_{t+i} is its profit income.

The problem can be decomposed in a wage-contracting problem where the wage is optimized with respect to all endogenous variables and a intra-contract period problem where the wage is taken as given and the optimal level of money, bond holdings, and consumption is chosen.

Wage-Contracting Problem Every time the household can change its wages, it has to solve the following optimization problem:

$$\max_{\left\{\mathsf{W}_t^*(ho)\right\}} E_t \sum_{i=0}^{\infty} \left(\beta\theta_w\right)^i \left[Ut\left(C_{t+i}\left(ho\right)\right) - Ut\left(N_{t+i}\left(ho\right)\right) + Ut\left(\frac{M_{t+i}\left(ho\right)}{P_{t+i}} \right) \right] \tag{38}$$

s.t.

$$E_t \sum_{i=0}^{\infty} \beta^i \left(C_{t+i} + \frac{R_t^{-1} B_{t+i} + M_{t+i}}{P_{t+i}} \right) \tag{39}$$

$$= \quad E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{W_t\,(ho)}{P_{t+i}} N_{t+i} + \frac{T_{t+i}}{P_{t+i}} + \frac{\Pi_{t+i}}{P_{t+i}} + \frac{B_{t+i-1}}{P_{t+i}} + \frac{M_{t+i-1}}{P_{t+i}} \right]$$

and

$$N_{t+i}(ho) = \left(\frac{W_t^*(ho)}{W_{t+i}} \right)^{-\epsilon_w} N_{t+i} \tag{40}$$

Since the product market is perfectly competitive, profit income is zero: $\frac{\Pi_{t+i}}{P_{t+i}} = 0$. Furthermore, for simplicity, we assume that the government refunds its seigniorage from money and bond creation to the households in the form of lump-sum transfers:

$$\frac{R_t^{-1} B_{t+i} + M_{t+i}}{P_{t+i}} = \frac{T_{t+i}}{P_{t+i}} + \frac{B_{t+i-1}}{P_t} + \frac{M_{t+i-1}}{P_t}. \tag{41}$$

Then the household's budget constraint reduces to

$$E_t \sum_{i=0}^{\infty} \beta^i C_{t+i} = E_t \sum_{i=0}^{\infty} \beta^i \frac{W_t\,(ho)}{P_{t+i}} N_{t+i}. \tag{42}$$

For analytical tractability, we make the usual assumption that households can insure themselves against idiosyncratic consumption shocks.[80] Thus:

$$P_{t+i} C_{t+i} = W_{t+i} N_{t+i}. \tag{43}$$

By substituting (40) and (43) into the utility function and taking the first derivative with respect to the wage, we obtain the following optimal wage:

$$W_t^*(ho) = \frac{\epsilon_w}{\epsilon_w - 1} \frac{E_t \sum_{i=0}^{\infty} (\beta\theta_w)^i \left[- Ut_N \left(N_{t+i}^d(ho) \right) \right] N_{t+i}^d(ho)}{E_t \sum_{i=0}^{\infty} (\beta\theta_w)^i \left[\frac{Ut_c(C_{t+i})}{P_{t+i}} \right] N_{t+i}^d(ho)} \tag{44}$$

In logs:

[80] For a more detailed description see e.g. Erceg et al. (2000).

$$w_t^*(ho) = \ln\left(\frac{\epsilon_w}{\epsilon_w - 1}\right) + \ln\left(E_t \sum_{i=0}^{\infty}(\beta\theta_w)^i \left[-Ut_N\left(N_{t+i}^d(ho)\right)\right] N_{t+i}^d(ho)\right)$$
$$- \ln\left(E_t \sum_{i=0}^{\infty}(\beta\theta_w)^i \left[\frac{Ut_C\left(C_{t+i}\right)}{P_{t+i}}\right] N_{t+i}^d(ho)\right) \qquad (45)$$

We log-linearize as follows:

$$w_t^*(ho) \approx \bar{w}^*(ho) + \sum_{i=0}^{\infty}\left[\begin{array}{c} \left[\frac{\partial w_t^*(i)}{\partial Ut_N}\frac{\partial Ut_N}{\partial \ln Ut_N}\right]_{equ}\left[\begin{array}{c}\ln\left[-Ut_N\left(N_{t+i}^d(ho)\right)\right]- \\ \ln\left[-Ut_N(N^d(ho))\right]\end{array}\right] \\ -\left[\frac{\partial w_t^*(i)}{\partial Ut_c}\frac{\partial Ut_c}{\partial \ln Ut_c}\right]_{equ}\left[\begin{array}{c}\log Ut_c\left(C_{t+i}\right)- \\ \log \bar{U}_c\left(C\right)\end{array}\right] \\ -\left[\frac{\partial w_t^*(i)}{\partial P_t}\frac{\partial P_t}{\partial p_t}\right]_{equ}\left(p_{t+i}-\bar{p}\right)\end{array}\right] \qquad (46)$$

which yields:

$$w_t^*(ho) \approx \mu_w + (1-\beta\theta_w)E_t\sum_{i=0}^{\infty}(\beta\theta_w)^i\left(\begin{array}{c}\ln\left[-Ut_N(N_{t+i}^d(ho))\right] \\ -\ln Ut_c\left(C_{t+i}\right)+p_{t+i}\end{array}\right) \qquad (47)$$

or put differently:

$$w_t^*(ho) \approx \mu_w + (1-\beta\theta_w)E_t\sum_{i=0}^{\infty}(\beta\theta_w)^i\left(\ln MRS_{t,t+i}+p_{t+i}\right) \qquad (48)$$

where $\mu_w = (\varepsilon_w/\left(\varepsilon_w - 1\right))$ is the steady state mark-up and $MRS_{t,t+i}$[81] is the marginal rate of substitution in period $t+i$ of households who set their wages in period t.

We can rewrite the individual marginal rate of substitution in terms of the average economy-wide marginal rate of substitution, by using the specific utility function (102):

[81] $MRS_{t,t+i} = -Ut_N(N_{t+i}^d(ho))/Ut_c\left(C_{t+i}\right)$

$$MRS_{t,t+i} = \left(\frac{W_{t+i}N_{t+i}}{P_{t+i}}\right)^{\sigma}\left(\left(\frac{W_t^*(ho)}{W_{t+i}}\right)^{-\epsilon_w} N_{t+i}\right)^{\varphi} \tag{49a}$$

$$= \left(\frac{W_{t+i}N_{t+i}}{P_{t+i}}\right)^{\sigma}\left(\left(\frac{W_{t+i}}{W_{t+i}}\right)^{-\epsilon_w} N_{t+i}\right)^{\varphi}\left(\frac{W_t^*(ho)^{-\epsilon_w}}{W_{t+i}^{-\epsilon_w}}\right)^{\varphi} \tag{49b}$$

$$= MRS_{t+i}\left(\frac{W_t^*(ho)^{-\epsilon_w}}{W_{t+i}^{-\epsilon_w}}\right)^{\varphi} \tag{49c}$$

where MRS_{t+i} is the average marginal rate of substitution in the economy.

Using (48), we obtain the following equation:

$$w_t^*(ho) = \mu_w + (1-\beta\theta_w)E_t\sum_{i=0}^{\infty}(\beta\theta_w)^i\left(mrs_{t+i} - \varphi\epsilon_w\left(w_t^*(ho) - w_{t+i}\right) + p_{t+i}\right). \tag{50}$$

Using the following approximate relationship for the aggregate wage index:

$$w_t = \theta_w w_{t-1} + (1-\theta_w)w_t^* \tag{51}$$

we obtain:

$$w_t = \theta_w w_{t-1} + (1-\theta_w)\frac{1}{1+\varphi\epsilon_w}\left[\mu_w + (1-\beta\theta_w)E_t\sum_{i=0}^{\infty}(\beta\theta_w)^i\left(mrs_{t+i} + \varphi\epsilon_w w_{t+i} + p_{t+i}\right)\right] \tag{52}$$

where mrs_{t+i} is the logarithm of MRS_{t+i}.

By iterating by one period forward and multiplying with $\beta\theta_w$:

$$\beta\theta_w E w_{t+1} = \beta\theta_w^2 w_t + (1-\theta_w)\frac{1}{1+\varphi\epsilon_w}\left[\begin{array}{c}\beta\theta_w\mu_w + (1-\beta\theta_w)E_t\sum_{i=0}^{\infty}(\beta\theta_w)^{i+1} \\ \left(mrs_{t+i+1} + \varphi\epsilon_w w_{t+i+1} + p_{t+i+1}\right)\end{array}\right] \tag{53}$$

Thus:

$$w_t - \beta\theta_w E_t w_{t+1} = \theta_w w_{t-1} - \beta\theta_w^2 w_t + \frac{1}{(1+\varphi\epsilon_w)}(1-\theta_w)(1-\beta\theta_w) \quad (54)$$
$$(mrs_t + \varphi\epsilon_w w_t + p_t) + (1-\theta_w)\frac{1}{1+\varphi\epsilon_w}(\mu_w - \beta\theta_w\mu_w)$$

where μ_w (constant) can be dropped when we take deviations from the steady state.

Intra-Contract Period Problem In each period the households have to choose on the optimal allocation of bonds, money holdings, and consumption. Thus the representative household maximizes its utility

$$\max_{\{C_{t+i}, B_{t+i}, M_{t+i}\}} E_t \sum_{i=0}^{\infty} \beta^i \left[Ut\left(C_{t+i}(ho)\right) - Ut\left(N_{t+i}(ho)\right) + Ut\left(\frac{M_{t+i}(ho)}{P_{t+i}}\right)\right] \quad (55)$$

subject to its budget constraint:

$$E_t \sum_{i=0}^{\infty} \beta^i \left(C_{t+i} + \frac{R_t^{-1} B_{t+i} + M_{t+i}}{P_{t+i}} \right) \quad (56)$$
$$= E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{W_t(ho)}{P_{t+i}} N_{t+i}(ho) + \frac{T_{t+i}}{P_{t+i}} + \frac{\Pi_{t+i}}{P_{t+i}} + \frac{B_{t+i-1}}{P_{t+i}} + \frac{M_{t+i-1}}{P_{t+i}} \right]$$

We obtain the following first order conditions via a Lagrangian

$$Ut_{C_t} = \beta R_t E_t \left(Ut_{C_{t+1}} \frac{P_t}{P_{t+1}} \right) \quad (57)$$

$$\frac{Ut_{M_t}}{Ut_{C_t}} = 1 - R_t^{-1}. \quad (58)$$

We optimize the following utility function

$$Ut\left(C_t(ho), \frac{M_t(ho)}{P_t}, N_t(ho) \right) = \frac{C_t^{1-\sigma}(ho)}{1-\sigma} + \frac{\left(\frac{M_t(ho)}{P_t}\right)^{1-\nu}}{1-\nu} - \frac{N_t^{1+\varphi}(ho)}{1+\varphi} \quad (59)$$

subject to its budget constraint

$$E_t \sum_{i=0}^{\infty} \beta^i \left(C_{t+i} + \frac{R_t^{-1} B_{t+i} + M_{t+i}}{P_{t+i}} \right) \tag{60}$$
$$= E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{W_t\,(ho)}{P_{t+i}} N_{t+i} + \frac{T_{t+i}}{P_{t+i}} + \frac{\Pi_{t+i}}{P_{t+i}} + \frac{B_{t+i-1}}{P_{t+i}} + \frac{M_{t+i-1}}{P_{t+i}} \right]$$

using (102):

$$\frac{\partial L}{\partial C_t} = C_t^{-\sigma} - \lambda_t = 0 \tag{61}$$

$$\frac{\partial L}{\partial C_{t+1}} = \beta C_{t+1}^{-\sigma} - \beta \lambda_{t+1} = 0 \tag{62}$$

$$\frac{\partial L}{\partial B_t} = R_t^{-1} \frac{1}{P_t} \lambda_t - \beta \frac{1}{P_{t+1}} \lambda_{t+1} = 0 \tag{63}$$

$$\frac{\partial L}{\partial M_t} = \frac{E_t M_t^{-\nu}}{E_t P_t^{1-\nu}} - \lambda_t \frac{1}{P_t} + \beta \lambda_{t+1} \frac{1}{P_{t+1}}. \tag{64}$$

Combining conditions (259), (266), and (63), we obtain the following consumption Euler equation:

$$1 = \beta R_t \left[\left(\frac{E_t C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{E_t P_{t+1}} \right) \right] \tag{65}$$

We use a first order Taylor approximation:

$$R_t \left[\left(\frac{E_t C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right] = (1 + r_t) E_t \left[\exp \left(-\sigma \Delta c_{t+1} - \pi_{t+1} \right) \right] \tag{66a}$$
$$\cong (1 + r_t) \left[1 - E_t \sigma \Delta c_{t+1} - E_t \pi_{t+1} \right] \tag{66b}$$
$$\cong (1 + r_t) - E_t \sigma \Delta c_{t+1} - E_t \pi_{t+1}. \tag{66c}$$

This delivers us equation (11).

When we plug (61) and (62) into (64), we obtain the following money demand equation:

$$\frac{\frac{E_t M_t^{-\nu}}{E_t P_t^{-\nu}}}{C_t^{-\sigma}} - 1 + \beta \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \frac{P_t}{P_{t+1}} = 0 \tag{67}$$

When we use the Euler consumption equation (65), we obtain:

$$\frac{\left(\frac{M_t}{P_t}\right)^{-\nu}}{C_t^{-\sigma}} = 1 - \frac{1}{1+r_t} \tag{68}$$

$$\frac{M_t}{P_t} = \left(\frac{1+r_t}{r_t} C_t^{\sigma}\right)^{\frac{1}{\nu}} \tag{69}$$

In logarithmic terms:

$$m_t - p_t = \frac{1}{\nu}\left(-\ln\frac{r_t}{1+r_t} + \sigma \ln C_t\right) \tag{70a}$$

$$= \frac{1}{\nu}\left(-\ln\left(1 - \frac{1}{e^{\ln(1+r_t)}}\right) + \sigma \ln C_t\right). \tag{70b}$$

We log-linearize and use $(1+r_t) \cong r_t$ for values close enough to zero:

$$\tilde{m}_t - \tilde{p}_t \cong \frac{\sigma}{\nu}\tilde{c}_t - \frac{1}{\nu}\frac{1}{1-\frac{1}{e^{\bar{r}}}}\frac{1}{e^{2-\bar{r}}}e^{\bar{r}}\tilde{r}_t \tag{71a}$$

$$= \frac{\sigma}{\nu}\tilde{c}_t - \frac{1}{\nu}\frac{1}{e^{\bar{r}}-1}\tilde{r}_t \tag{71b}$$

$$\cong \frac{\sigma}{\nu}\tilde{c}_t - \frac{1}{\nu}\frac{1}{\bar{r}}\tilde{r}_t \tag{71c}$$

The Firms' Problem In the wage staggering model firms are price takers. Thus the prices are equal to the nominal marginal costs.[82]

$$p_{t+i} = mc^{no}_{t+i}. \tag{72}$$

3.7.2 Price Staggering Model

Household's Optimization Problem: In contrast to the pure wage staggering model households maximize their utility also with respect to the working time in the price staggering model, as they do not have any wage setting power and thus they are wage takers.

[82] The market clearing conditions will be shown after the derivation of the first order conditions of the price-staggering model.

$$
\begin{aligned}
&\max_{\{C_{t+i},B_{t+i},\mathsf{M}_{t+i},N_{t+i}\}} E_t \sum_{i=0}^{\infty} \beta^i \left[Ut\left(C_{t+i}(ho), \frac{M_{t+i}(ho)}{P_{t+i}}, N_{t+i}(ho) \right) \right] \\
= &\left[E_t \sum_{i=0}^{\infty} \beta^i \left(\frac{C_{t+i}^{1-\sigma}(ho)}{1-\sigma} + \frac{\left(\frac{M_{t+i}(ho)}{P_{t+i}}\right)^{1-\nu}}{1-\nu} - \frac{N_{t+i}^{1+\varphi}(ho)}{1+\varphi} \right) \right] \qquad (73)
\end{aligned}
$$

subject to its budget constraint

$$
\begin{aligned}
&E_t \sum_{i=0}^{\infty} \beta^i \left(C_{t+i} + \frac{R_t^{-1} B_{t+i} + M_{t+i}}{P_{t+i}} \right) \qquad (74) \\
= \ &E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{W_t(ho)}{P_{t+i}} N_{t+i} + \frac{T_{t+i}}{P_{t+i}} + \frac{\Pi_{t+i}}{P_{t+i}} + \frac{B_{t+i-1}}{P_{t+i}} + \frac{M_{t+i-1}}{P_{t+i}} \right].
\end{aligned}
$$

This yields the same two following first order conditions as before (for the derivation see wage staggering model):

$$
1 = \beta R_t \left[\left(\frac{E_t C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{E_t P_{t+1}} \right) \right] \qquad (75)
$$

$$
\frac{M_t}{P_t} = \left(\frac{1+r_t}{r_t} C_t^{\sigma} \right)^{\frac{1}{\nu}}. \qquad (76)
$$

The consumption Euler equation and the money demand equation can be log-linearized as in the wage staggering model.

In addition, we get the following labor supply equation when we take the first derivative with respect to the utility function and use equation (259):

$$
\frac{W_{t+i}}{P_{t+i}} = -\frac{N_{t+i}^{\varphi}}{C_{t+i}^{\sigma}} = MRS_{t+i} \qquad (77)
$$

or alternatively in logs:

$$
w_{t+i} - p_{t+i} = c_{t+i}^{\varphi} + n_{t+i}^{\sigma} = mrs_{t+i}. \qquad (78)
$$

When households are wage takers, the real wage is always equal to the marginal rate of substitution.

Firms' Maximization Problem: The firms' maximization problem in the price-staggering model is similar to the households optimization problem in the wage staggering model. The firms maximize

$$\max_{\{P_t^*(j)\}} E_t \sum_{i=0}^{\infty} (\beta\theta_p)^i \left(P_t^*(j)\, Y_t(j) - N_t(j)\, W_t(j)\right) \tag{79}$$

subject to the production function

$$Y_t(j) = A_t N_t(j)^{1-\alpha} \tag{80}$$

and

$$Y_{t+i}(j) = \left(\frac{P_t^*(j)}{P_{t+i}}\right)^{-\varepsilon_p} Y_{t+i}. \tag{81}$$

We get the following first order condition:

$$E_t \sum_{i=0}^{\infty} (\beta\theta_p)^i \left((1-\varepsilon_p)\, P_t^*(j)\, Y_{t,t+i} + \frac{\varepsilon_p}{1-\alpha} W_{t+i} N_{t,t+i}(j)\right) = 0. \tag{82}$$

where $_{t,t+i}$ indicates the value of the variable in period $t+k$ when prices were set in period t.

This can be rewritten as:

$$E_t \sum_{i=0}^{\infty} (\beta\theta_p)^i \left(Y_{t,t+i}\left(P_t^*(j) - \frac{\varepsilon_p}{\varepsilon_p - 1} MC_{t,t+i}^{no}\right)\right) = 0. \tag{83}$$

Thus we obtain:

$$P_t^*(j) = \frac{\varepsilon_p}{\varepsilon_p - 1} \frac{E_t \sum_{i=0}^{\infty} (\beta\theta_p)^i\, Y_{t,t+i} MC_{t,t+i}^{no}}{E_t \sum_{i=0}^{\infty} (\beta\theta_p)^i\, Y_{t,t+i}}. \tag{84}$$

By using a first order Taylor approximation:

$$p_t^*(j) \approx \mu_p + (1-\beta\theta_p) E_t \sum_{i=0}^{\infty} (\beta\theta_p)^i mc_{t,t+i}^{no} \tag{85}$$

where $\mu_p = \frac{\varepsilon_p}{\varepsilon_p - 1}$ is the steady state mark-up over nominal marginal costs.

With decreasing returns to labor the firm specific marginal cost are not necessarily equal to the economy-wide average marginal costs.

Firm-specific real marginal costs:

$$MC_{t,t+i}^{re} = \frac{W_{t+i}/P_{t+i}}{(1-\alpha)(Y_{t,t+i}/N_{t,t+i})}. \tag{86}$$

Average real marginal costs in the economy:

$$MC_{t+i}^{re} = \frac{W_{t+i}/P_{t+i}}{(1-\alpha)(Y_{t+i}/N_{t+i})}. \tag{87}$$

Using (86) and (87) reformulating:

$$MC_{t,t+i}^{re} = MC_{t+i}^{re} \left(\frac{P_t^*}{P_{t+k}}\right)^{\frac{-\varepsilon\alpha}{1-\alpha}}. \tag{88}$$

When we log-linearize, we obtain

$$\tilde{m}c_{t,t+i}^{re} = \tilde{m}c_{t+i}^{re} - \frac{\varepsilon_p \alpha}{1-\alpha}\left(p_t^* - \tilde{p}_{t+i}\right). \tag{89}$$

Plugging in and reformulating:

$$\tilde{p}_t^*(ho)\left(1+\frac{\varepsilon\alpha}{1-\alpha}\right) = (1-\beta\theta_p)E_t\sum_{i=0}^{\infty}(\beta\theta_p)^i\left(\tilde{m}c_{t+i}^{re} + \frac{1-\alpha+\varepsilon\alpha}{1-\alpha}\tilde{p}_{t+k}\right). \tag{90}$$

where $\hat{m}c_{t+k}^{re}$ is the deviation from the steady state of the average economy-wide real marginal costs.

We use the approximate relation

$$\tilde{p}_t = \theta_p \tilde{p}_{t-1} + (1-\theta_p)p_t^* \tag{91}$$

and use the same forward iteration as for wage setting, we obtain the following Phillips curve relationship:

$$\tilde{\pi}_t = \beta E_t \tilde{\pi}_{t+1} + \frac{(1-\theta_p)(1-\beta\theta_p)(1-\alpha)}{\theta_p[1+\alpha(\varepsilon-1)]}\tilde{m}c_t^{re}. \tag{92}$$

When we log-linearize the average economy-wide marginal costs from above, we obtain:

$$\tilde{m}c_t^{re} = \tilde{w}_t - \tilde{p}_t + \frac{\alpha}{1-\alpha}\tilde{y}_t - \frac{1}{1-\alpha}\tilde{a}_t \tag{93}$$

where the productivity term can be skipped, when we assume that there are no productivity shocks ($\tilde{a}_t = 0$).

3.7.3 Closing the System

The following conditions hold for all three models (price staggering, wage staggering, and both types of staggering).

Goods Market Clearing: In this simple version of the model we have the following goods market clearing condition:

$$Y_t = C_t. \tag{94}$$

Or in logarithms:

$$y_t = c_t. \tag{95}$$

Thus we can derive the following equation from the Euler consumption equation (106):

$$\tilde{y}_t = E_t(\tilde{y}_{t+1}) - \frac{1}{\sigma}(r_t - E_t(\pi_{t+1}) + rr_t) \tag{96}$$

where rr_t is the natural rate interest. When we plug in the money demand function (12), we obtain (30), which is the same for all three dynamic systems:

$$E_t\tilde{y}_{t+1} + \frac{1}{\sigma}E_t\tilde{p}_{t+1} + \frac{1}{\sigma\iota}\left(\tilde{m}_t - \tilde{p}_t\right) = \left(1 + \frac{1}{\sigma\iota}\right)\tilde{y}_t + \frac{1}{\sigma}\tilde{p}_t. \tag{97}$$

Production Function: Furthermore, to close the system, we have to use the production function (1). Up to a first order approximation[83] it can be shown that:

$$y_t = a_t + (1-\alpha)\, n_t. \tag{98}$$

Thus the following relationships for deviations of the marginal rate of substitution from the steady state can be derived, when we take deviations from the steady state, assume no productivity shocks ($\tilde{a}_t = 0$) and use equation (78) for the marginal rate of substitution:

$$m\tilde{r}s_t = (\sigma + \varphi\frac{1}{(1-\alpha)})\tilde{y}_t. \tag{99}$$

Furthermore, using (93), with $\tilde{a}_t = 0$, the following equation is valid:

$$\tilde{p}_t = \tilde{m}c_t^{no} = \tilde{w}_t + \frac{\alpha}{1-\alpha}\tilde{y}_t. \tag{100}$$

[83] The derivation is available on request.

Money Supply Equation: Furthermore the following condition holds:

$$m_t = m_{t-1} + \Delta m_t. \tag{101}$$

3.7.4 The Three Dynamic Systems

We can define all three dynamic systems by using the equations above. As mentioned, equation (96), which is derived from the Euler consumption equation and which can be rewritten as an IS-type equation (97) [84], holds in all three cases.

For the wage staggering model, we use the wage dynamics equation (54), take derivations from the steady state, use (99) and express prices in terms of wages (54) to obtain equation (17).

For the price-staggering model equations (78), (92) and (93) are used to obtain (134).

For the wage- and price-staggering model equations (92) and (93) are used to derive the Phillips curve relationship. Furthermore, when taking deviations from the steady state (54) and using (99), the wage dynamics equation (32) can be obtained.

[84] The only difference is that we expressed the IS-type equation in terms of wages in the wage-staggering model.

4 Real Wage Rigidities and the Cost of Disinflation

4.1 Introduction

In a very insightful paper Blanchard and Galí (2007) advocate the introduction of real wage rigidities in the standard new Keynesian (NK) model. They show that real wage rigidities would generate both more realistic policy trade-offs, by breaking what Blanchard and Galí (2007) called the *divine coincidence,* and a more realistic empirical behavior of inflation, by generating inflation inertia.

In order to show an example of these two previous features brought about by the introduction of real wage rigidities, in Section 4, Blanchard and Galí (2007) look at the cost of a classical monetary policy experiment: a disinflation (from 4% to zero).

In this chapter[85], we show that, like others in the literature, the analysis in Blanchard and Galí (2007) is flawed because it abstracts from non-linearities, being based on the log-linear formulation of the standard NK model. Such a procedure is clearly not suited for analyzing the response of the model after a disinflation, since the standard NK model is non-linear, giving rise to non-superneutrality of money. A disinflation experiment is therefore a movement from one steady state to a different one and cannot be analyzed by log-linearizing the model around one of the two steady states.

It may be argued that a log-linear analysis is valid in an approximated sense if the model is "almost" linear. This chapter demonstrates that this is not the case. Indeed, we show that the results in Section 4 in Blanchard and Galí (2007) are inaccurate both qualitatively and quantitatively.

4.2 The Model

The model is as in Blanchard and Galí (2007), that is, a standard NK model, except for the real wage rigidity. Other than Blanchard and Galí (2007) we add real money balances in the utility function because a disinflation describes a path for the money supply and therefore we do need money demand.

[85] For a different version of this chapter see "Real Wage Rigidities and the (Real) Cost of Disinflation - A Comment on Blanchard and Galí -" with Guido Ascari, mimeo, January 2007.

4.2.1 Households

We use the following instantaneous and separable utility function, with the standard long-run properties[86]

$$Ut\left(C_t\left(ho\right), \frac{M_t\left(ho\right)}{P_t}, N_t\left(ho\right)\right) = \frac{C_t^{1-\sigma}}{1-\sigma} + d_m \frac{\left(\frac{M_t(ho)}{P_t}\right)^{1-\nu}}{1-\nu} - d_e \frac{N_t^{1+\varphi}\left(ho\right)}{1+\varphi}, \tag{102}$$

where C is composite consumption (with elasticity of substitution between different types of goods equal to ε_p).

The household is subject to the following budget constraint

$$P_t C_t + \left(1+r_t\right)^{-1} B_t + M_t = W_t N_t - T_t + \Pi_t + B_{t-1} + M_{t-1},$$

where r_t is the nominal interest rate, B_t are one-period bond holdings, M_t is the nominal money supply, W_t is the nominal wage rate, N_t is the labor input, T_t are lump sum taxes, and Π_t is the profit income, which is transferred to consumers. The representative consumer maximizes the intertemporal utility (using the discount factor β)

$$\max_{\{C_t, W_t, B_t, M_t\}} E_0 \sum_{t=0}^{\infty} \beta^t Ut\left(C_t\left(ho\right), \frac{M_t\left(ho\right)}{P_t}, N_t\left(ho\right)\right), \tag{103}$$

yielding the following first order conditions.[87]

Money demand equation:

$$\frac{Ut_m}{Ut_C} = \frac{d_m C_t^{\sigma}}{m_t^{\nu}} = \frac{r_t}{1+r_t} \tag{104}$$

Labor supply equation:

$$\frac{W_t}{P_t} = -\frac{Ut_N}{Ut_C} = \frac{d_e N_t^{\varphi}}{1/C_t^{\sigma}} = d_e N_t^{\varphi} C_t^{\sigma} \tag{105}$$

Euler equation:

$$\frac{1}{C_t^{\sigma}} = \beta E_t \left[\left(\frac{P_t}{P_{t+1}}\right)\left(1+r_t\right)\left(\frac{1}{C_{t+1}^{\sigma}}\right)\right] \tag{106}$$

Blanchard and Galí (2007) assume the following ad-hoc[88] partial adjust-

[86] Throughout the chapter, capital letters refer to levels, whereas small letters denote the logarithm of a variable.

[87] For a detailed derivation see Technical Appendix of chapter 3.

[88] The ad hoc real wage adjustment rule is very much at odds with the idea of the New

ment for the real wage: $w_t/p_t = \gamma\left(w_{t-1}/p_{t-1}\right) + (1-\gamma)mrs_t$, where mrs_t is the marginal rate of substitution between consumption and labor supply in logarithms and w_t/p_t is the real wage in logarithms. Accordingly, we add the same real wage rigidities to the model, but in a non-linear fashion, that is

$$\frac{W_t}{P_t} = \left(\frac{W_{t-1}}{P_{t-1}}\right)^{\gamma} (MRS_t)^{1-\gamma}. \tag{107}$$

$$\frac{W_t}{P_t} = \left(\frac{W_{t-1}}{P_{t-1}}\right)^{\gamma} MRS_t^{1-\gamma} = \left(\frac{W_{t-1}}{P_{t-1}}\right)^{\gamma} \left(-\frac{Ut_{N_t}}{Ut_{C_t}}\right)^{1-\gamma} \tag{108}$$

$$\frac{W_t}{P_t} = \left(\frac{W_{t-1}}{P_{t-1}}\right)^{\gamma} \left(d_e N_t^{\varphi} C_t^{\sigma}\right)^{1-\gamma} \tag{109}$$

4.2.2 Firms

Final good producers use the following aggregation technology

$$Y_t = \left[\int_0^1 Y_{i,t}^{\frac{\varepsilon_p - 1}{\varepsilon_p}} di\right]^{\frac{\varepsilon_p}{\varepsilon_p - 1}} \tag{110}$$

Their demand for intermediate inputs is therefore equal to

$$Y_{i,t+j} = \left(\frac{P_{i,t}}{P_{t+j}}\right)^{-\varepsilon_p} Y_{t+j} \tag{111}$$

Firms' pricing is described by the usual Calvo mechanism, where θ_p is the fraction of firms not adjusting their price in any given period.

Under no indexation[89] the problem of a price-resetting firm can be formulated as

$$\max_{P_{i,t}} \quad E_t \sum_{j=0}^{\infty} \theta_p^j \Delta_{t,t+j} \left[\frac{P_{i,t}}{P_{t+j}} Y_{i,t+j} - TC_{t+j}^{re}\left(Y_{i,t+j}\right)\right] \tag{112}$$

$$s.t. \quad Y_{i,t+j} = \left(\frac{P_{i,t}}{P_{t+j}}\right)^{-\varepsilon_p} Y_{t+j} \tag{113}$$

where $P_{i,t}$ denotes the new optimal price of producer i and $TC_{t+j}^{re}\left(Y_{i,t+j}\right)$ the real total cost function and $\Delta_{t,t+j}$ is the stochastic discount factor (from period t to period $t+j$). The solution to this problem yields the familiar formula for

Keynesian literature to derive macroeconomic equations from first microeconomic principles. A deeper critique goes beyond the scope of this chapter, which takes the real wage rigidity as given and points out other weaknesses of the paper by Blanchard and Galí (2007).

[89] See Technical Appendix for the case with indexation to long-run inflation.

the standard optimal resetted price in a Calvo setup

$$P_{i,t}=\left(\frac{\varepsilon_p}{\varepsilon_p-1}\right)\frac{E_t\sum_{j=0}^{\infty}\theta_p^j\Delta_{t,t+j}\left[P_{t+j}^{\varepsilon_p}Y_{t+j}MC_{i,t+j}^{re}\right]}{E_t\sum_{j=0}^{\infty}\theta_p^j\Delta_{t,t+j}\left[P_{t+j}^{\varepsilon_p-1}Y_{t+j}\right]} \tag{114}$$

where $MC_{i,t}^{re}$ denotes the real marginal costs function.

This can be substituted as

$$\frac{P_{i,t}}{P_t}=\left(\frac{\varepsilon_p}{\varepsilon_p-1}\right)\left(\frac{NU_t}{DN_t}\right), \tag{115}$$

where

$$NU_t=Ut_C\left(t\right)Y_tMC_{i,t}+\theta_p\beta E_t\left(\pi_{t+1}^{\varepsilon_p}NU_{t+1}\right), \tag{116}$$

and

$$DN_t=Ut_C\left(t\right)Y_t+\theta_p\beta E_t\left(\pi_{t+1}^{\varepsilon_p-1}DN_{t+1}\right) \tag{117}$$

where $\pi_{t+1}\equiv\frac{P_{t+1}}{P_t}$.

The aggregate price level evolves according to

$$P_t = \left[\int_0^1 {P_{i,t}}^{1-\varepsilon_p}di\right]^{\frac{1}{1-\varepsilon_p}} \Longrightarrow \tag{118}$$

$$1 = \left[\theta_p{\pi_t}^{\varepsilon_p-1}+(1-\theta_p)\left(\frac{P_{i,t}}{P_t}\right)^{1-\varepsilon_p}\right]^{\frac{1}{1-\varepsilon_p}} \tag{119}$$

4.2.3 Technology

Firms produce a differentiated product using the following production function

$$Y_t=F^{\alpha}N_t^{1-\alpha} \tag{120}$$

where Y is output, and F and N are non-produced[90] and labor inputs, respectively.

For simplicity, we omit F_t^{α} (since we are not explicitly interested in a cost push shock).

[90] We deviate slightly from the notation by Blanchard and Galí (2007) who use the letter M for the non-produced good, which we reserved for money.

The labor demand and the real marginal cost of firm i is therefore

$$N_{i,t}^d = [Y_{i,t}]^{\frac{1}{1-\alpha}} \tag{121}$$

$$MC_{i,t}^{re} = \frac{1}{1-\alpha}\frac{W_t}{P_t}Y_{i,t}^{\frac{\alpha}{1-\alpha}}. \tag{122}$$

Note that now marginal costs depend upon the quantity produced by the single firm, given the decreasing returns to scale. In other words, different firms charging different prices would produce different levels of output and hence have different marginal costs.

Express $MC_{i,t}^{re}$ as

$$\begin{aligned} MC_{i,t}^{re} &= \frac{1}{1-\alpha}\frac{W_t}{P_t}Y_{i,t}^{\frac{\alpha}{1-\alpha}} \\ &= \frac{1}{1-\alpha}\frac{W_t}{P_t}\left[\left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon_p} Y_t\right]^{\frac{\alpha}{1-\alpha}}. \end{aligned} \tag{123}$$

4.2.4 Aggregation and Price Dispersion

The aggregate resource constraint is now simply given by

$$Y_t = C_t \tag{124}$$

and the link between aggregate labour demand and aggregate output is provided by

$$\begin{aligned} N_t^d &= \left[\int_0^1 N_{i,t}^d di\right] = \left[\int_0^1 \left[\left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon_p} Y_t\right]^{\frac{1}{1-\alpha}} di\right] = \\ &= [Y_t]^{\frac{1}{1-\alpha}} \underbrace{\int_0^1 \left[\left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon_p}\right]^{\frac{1}{1-\alpha}} di}_{s_t} = s_t\,[Y_t]^{\frac{1}{1-\alpha}}, \end{aligned} \tag{125}$$

where

$$s_t = \int_0^1 \left[\left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon_p}\right]^{\frac{1}{1-\alpha}} di \tag{126}$$

is a sort of tax due to price distortions (and the non-linearity of the aggregator). Schmitt-Grohé and Uribe (2007) show that s_t is bounded below at one, so that s_t represents the resource costs due to relative price dispersion under the Calvo mechanism with long-run inflation. Indeed, the higher s_t, the more labor is needed to produce a given level of output. Note that s_t can also be rewritten as a ratio between two different price indexes P_t and $\widetilde{P}_t$

$$s_t = \left(\frac{P_t}{\widetilde{P}_t}\right)^{\varepsilon_p} \text{ where } \widetilde{P}_t = \left[\int_0^1 P_t(i)^{-\varepsilon_p}\, di\right]^{-1/\varepsilon_p}, \tag{127}$$

as in Ascari (2004). Whenever there is price dispersion these two indexes evolve differently from each other, determining a certain dynamics for s_t, that affects the level of production negatively . s_t would not affect the real variables up to first order whenever there is no trend inflation (i.e., $\bar{\pi} = 1$) or whenever the resetted price is fully indexed to any variable whose steady state level grows at the rate $\bar{\pi}$.

To close the model we just need to solve for the dynamic of s using (126).

$$s_t = \int_0^1 \left[\left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon_p}\right]^{\frac{1}{1-\alpha}} di \tag{128}$$

$$s_t = (1-\theta_p)\left[\frac{P_{i,t}}{P_t}\right]^{-\frac{\varepsilon_p}{1-\alpha}} + \theta_p \pi_t^{\frac{\varepsilon_p}{1-\alpha}} s_{t-1} \tag{129}$$

4.2.5 System of Equations

The following equations are simulated non-linearly: (104), (105), (106), (115), (117), (116), (119), (121), (122), and (129).

The money supply identity equation closes the system

$$m_{t-1} rgm_t = m_t \pi_t, \tag{130}$$

where rgm_t is the rate of growth of money, which is reduced under a disinflation.

In the presence of a real wage rigidity, equation (105) is replaced by equation (109).

4.3 Calibration

We calibrate the money demand in the same way as in Chari et al. (2000, pp. 1160 f.) who estimated the parameters for the United States[91]. While they

[91] Chari et al. (2000, p. 1161) use time series from Citibase for the observation period 1960:1 to 1995:4.

have a non-separable utility function, we used a separable form as in Blanchard and Galí (2007).

Given the money demand

$$d_m C_t^\sigma (1 + r_t) = r_t m_t^\nu \tag{131}$$

and taking the logarithm

$$\ln m_t = \frac{\ln d_m}{\nu} + \frac{\sigma}{\nu} \ln C_t - \frac{1}{\nu} \ln \left(\frac{r_t}{1 + r_t} \right) \tag{132}$$

we obtain the same analytical form as Chari et al. (2000) (p. 1161, see equation (25)):

$$\ln \frac{M(s^t)}{\bar{P}(s^t)} = -\iota \ln \frac{\omega}{1 - \omega} + \ln c(s^t) - \iota \ln \left(\frac{R(s^t) - 1}{R(s^t)} \right) \tag{133}$$

To obtain the same interest rate elasticity of money demand, we set $\nu = 2.5641$ (Chari et al., 2000: $\iota = 0.39$). To obtain the same output elasticity, we set $\sigma = 2.5641$ as well (Chari et al., 2000: $\omega = 0.94$). Furthermore, d_m is set to 0.063832.

As in Chari et al. (2000), $d_e$is calibrated in such a way that people devote one third of their time to work (under zero steady state inflation). The elasticity of substitution between different product types (ε_p) is set to 10.

Furthermore, we use a standard quarterly discount rate of one percent ($\beta = 0.99$) and a quadratic disutility of labor ($\varphi = 1$), see e.g. Galí (2003). The quarterly probability of not re-setting the prices (θ_p) is either set to 50 percent (see Bils and Klenow, 2004) or to 75 percent, as in most of the calibrations in the literature. The degree of decreasing returns to labor $(1 - \alpha)$ is either 0.975 (Blanchard and Galí (2007) write that the share of oil in production is roughly 2.5 percent) or 0.67 (as in Chari et al., 2000) in our calibration.

Moreover, we also consider the case where non-resetting firms automatically and fully index their prices to the steady state inflation rate (see Appendix for details). This is motivated by the fact that full indexation is the only way to obtain the standard New Keynesian Phillips curve (i.e., $\pi_t = \beta E_t \pi_{t+1} + \kappa y_t$, as used by Blanchard and Galí, 2007) by log-linearizing the model around the steady state, independently of the steady state inflation rate (see Ascari, 2004).

We experimented also with log-utility in consumption as in Blanchard and Galí (2007) with no substantial difference in the results. The qualitative results of this chapter do not depend at all on the chosen calibration, unless stated.

4.4 Disinflation

4.4.1 Steady State Effects

The obvious starting point to analyze a disinflation experiment is to look at the steady state, since the standard NK model is non-linear and non-superneutrality arises. In this respect Blanchard and Galí (2007, p. 19[92]) write: "As is well known, the standard NKPC implies the presence of a long run trade-off, however small, between inflation and the output gap. (...) in the standard NK model, disinflation implies a permanently lower level output."

Blanchard and Galí (2007) use the standard linearized Phillips curve to make their point:

$$\pi_t = \beta \pi_{t+1} + \kappa y_t \tag{134}$$

Dropping the time indices implies a positive long-run trade-off between inflation and output: $y = \frac{1-\beta}{\kappa}\pi$. Figure (7) below shows that this conclusion is an artifact of the linearization.[93] Indeed, while it is true that the tangent of the curve in the graph at zero inflation exhibits a positive slope equal to $\frac{1-\beta}{\kappa}$, the relationship between steady state output and inflation is non-linear. The effects of non-linearities are quite powerful and turn up very quickly, inverting the relationship from positive to negative (see Ascari and Rankin, 2002, Ascari, 2004 and Yun, 2005).[94]

Quite obviously the strength of the steady state effects due to the non-linearities depends on the parameters governing them, and in particular α, θ_p and φ. In this respect, we show the graphs for the two values of α (the degree of decreasing returns to labor) used by Blanchard and Galí (2007), and $\theta_p = 0.5$ (probability of not re-setting the prices), following Bils and Klenow (2004), as well as $\theta_p = 0.75$, by far the value most commonly used in the literature, see e.g. Galí (2003).

Our simulations show that non-linearities make the steady state relationship between inflation and output more complex than described by Blanchard and Galí (2007). Indeed, it may be positive only for very small level of in-

[92] Note that the page numbers refer to the revised online version on the website of Jordi Galí (see reference list for the link), since the published article is forthcoming.

[93] In figure (7), steady state output at zero inflation was normalized to one, and quarterly inflation rates are annualized.

[94] In the language of Graham and Snower (2004), BG only take the "time discounting effect" into account, whereas they ignore the "employment cycling" and "labor supply smoothing" effects.

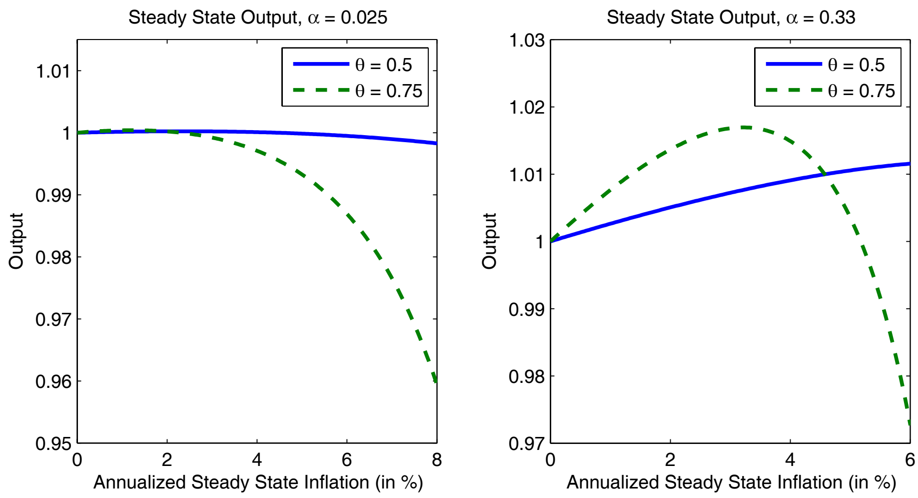


Figure 7: Steady state relationship between output and (annualized) inflation

flation, if $\alpha = 0.025$; or it can instead reach a maximum for sizeable positive inflation levels, if $\alpha = 0.33$ (7.1% if $\theta_p = 0.5$, 3.2% if $\theta_p = 0.75$). It follows that the long-run effects of the Blanchard and Galí (2007) disinflation experiment, i.e., from 4% to zero, are ambiguous and can be sizeable, depending on the calibration chosen. Finally, it is worth noting that the long-run effects depend very much on the particular starting point. Steady state output changes are very different when disinflating from 8% to 4%, rather than from 4% to zero (see Ascari, 2004).

Some authors may argue that at least in analyzing the steady state properties of the standard NK model one should allow for indexation. Partial indexation would flatten and move the output peak somewhat to the right, but would in any case not be reconcilable with Blanchard and Galí's (2006) linearized equations. And complete indexation to steady state inflation would lead to an entirely vertical (flat in our figure (7)) long-run Phillips curve, thus wiping out any trade-off.

4.4.2 Disinflation Dynamics

4.4.3 Standard New Keynesian Model

Blanchard and Galí (2007, p. 16) make the following qualitative statement: "Hence, at the time of disinflation (period 0) output declines by $dy(0) = -\frac{1-\beta}{\kappa}\pi^*$, remaining at the lower level thereafter, with no additional transitional dynamics coming into play." They argue quantitatively (p. 16-17): "In the standard NK model, the real effects of disinflations mentioned above tend to

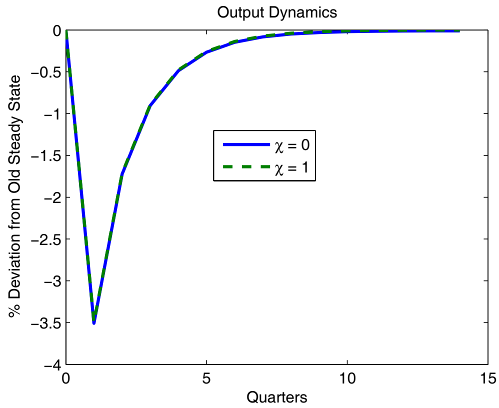


Figure 8: Output response after a disinflation from 4% to 0

be small, at least for plausible parameter values."

Blanchard and Galí's (2007) assessment of the effects of a disinflation in a standard NK model is based on a specific log-linearized version of the model, and is hence inevitably going to be mistaken both qualitatively and quantitatively.

Figure (8) shows the output dynamics (in percentage deviation) in the standard NK model, following a sudden decrease in the rate of growth of money from 4% to zero, as in Blanchard and Galí (2007).[95] From a qualitative point of view, it is evident that transitional dynamics comes into play, and they do not necessarily seem to be at odds with empirical observations: output drops on impact and then sluggishly returns to its new steady state value after roughly two years and a half. From a quantitative point of view, the effects are quite big: the slump on impact is about 3.5% of the starting output level, and output remains below steady state all along the adjustment path. It is worth stressing that this path is obtained for the standard microfounded NK model and standard calibration values.[96]

To sum up, Blanchard and Galí (2007) write that the standard NK model cannot capture the empirical evidence of the negative effects of a disinflation. "The decline around the time of disinflation seems substantially smaller than in actual disinflationary episodes, as reported in Ball (1994)." (p. 17) Again,

[95] In figure (8) , we thus set $\gamma = 0$ and use the benchmark calibration. The paths displayed in figure (8) and onwards are obtained using the software DYNARE developed by Juillard (1996) and others at CEPREMAP.

[96] As it is well-known, a microfounded money demand is crucial to obtain such a path (see, e.g., Blanchard and Fischer, 1989, chp. 10, Ascari and Rankin, 2002 and references therein).

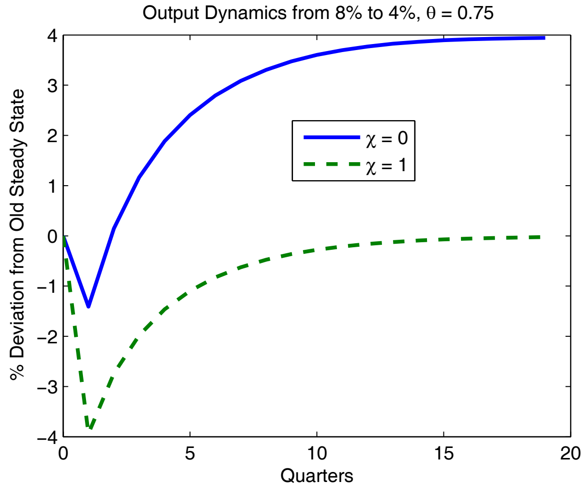


Figure 9: Output response after a disinflation from 8% to 4%

we instead claim that the linearization and not the complete microfoundation as such is responsible for this feature, and thus not the NK model *per se*.

A Remark: In Figure (8) we plot two paths for two different cases: no indexation ($\chi = 0$) and full indexation ($\chi = 1$) to the steady state rate growth rate of money. For the benchmark calibration, the two paths are almost identical, showing that our result does not depend on the degree of indexation. The reader should anyway keep in mind that indexation would matter more, whenever effects arising from non-linearities are stronger. Indeed, given the benchmark calibration in figure (8), the old and new steady states are very close. However, whenever the long-run effects are sizeable instead (because of different starting inflation values and/or different calibration), indexation would obviously also matter for the dynamic adjustment path. This is an important point, exemplifying how long-run effects and short-run dynamics interrelate with each other in a full non-linear model. Just as an illustration, figure (9) shows the output dynamics following a disinflation from 8% to 4% when $\theta_p = 0.75$, under the two cases of no and full indexation (see Ascari and Ropele, 2006).

4.4.4 Real Wage Rigidities

Blanchard and Galí (2007, p. 18) write: "Hence, a permanent reduction in inflation of 4 percentage points in (annualized) inflation lowers the level of output by roughly 50 basis points in the quarter the policy is implemented, an effect about 10 times larger than in the standard model." They claim that

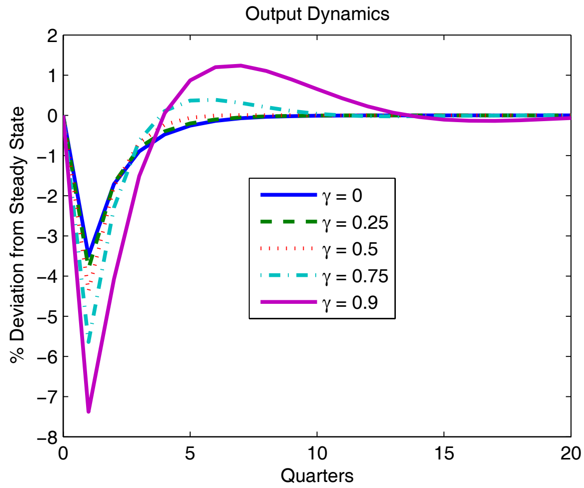


Figure 10: The effect of real rigidities on the output response to a disinflation

real wage rigidities: (i) are necessary to obtain a dynamic response of output after a disinflation, and (ii) they increase the impact effect on output and thus the overall costs of a disinflation manifold. We already saw that the first point is not true, since a dynamic path for output is obtained in the standard model without the need for any real rigidities.

Figure (10) shows that Blanchard and Galí's (2007) assessment of the role that real rigidities play for the dynamic adjustment after a disinflation is qualitatively right.[97] Indeed, real wage rigidities cause stronger and more persistent effects on output. From a quantitative point of view, however, the effects are by no means of the order of magnitude suggested by Blanchard and Galí (2007). In the extreme case assumed by Blanchard and Galí (2007), i.e., $\gamma = 0.9$, the impact effect is only twice as large as in the standard model. Moreover, during the adjustment, output oscillates and the sudden slump is followed by a prolonged boom that partly compensates the initial output loss, with respect to the case without real wage rigidities, where convergence is instead monotonic. Moreover, figure (10) does not suggest a "relatively fast convergence to the new steady state."

Finally it is worth noting that only very extreme values of γ tend to have sizeable effects on the output response, since for values smaller than 0.5, the quantitative effects of real rigidities are small (more on that in the next subsection).

[97]In Figure (10) and in the following ones, we assume full indexation, benchmark calibration and again 4% to zero disinflation experiment. Note that the steady state values do not depend on γ. The paths for output would be almost identical if we had assumed no indexation.

Blanchard and Galí (2007) stress the importance of real rigidities for inflation dynamics. Indeed, in Section 6 of their article, Blanchard and Galí (2007) show that real wage rigidities are able to generate inflation inertia and give raise to a log-linearized Phillips curve equation which is very similar to the ad hoc specification used in the empirical literature. This point can be visualized by plotting the dynamic response of inflation, as in figure (9). Inflation indeed displays more inertia for higher values of γ. Moreover, for the calibration chosen by Blanchard and Galí (2007), i.e., $\gamma = 0.9$, inflation exhibits a hump-shaped response. However, (i) again only extreme values of γ tend to have significant effects; (ii) the numbers are rather disconcerting. Inflation falls immediately with little inertia whatsoever in any case: the first quarter after the disinflation, inflation is -50% (in annualized terms) if $\gamma = 0$, and -24% if $\gamma = 0.9$. The reason lies in the fact that during the adjustment phase the price level has to decrease in order to generate a higher level of real balances to satiate the increase in money demand brought about by the disinflation (see, e.g. Blanchard and Fischer, 1989, chapter 10, Ascari and Rankin, 2002 and references therein).

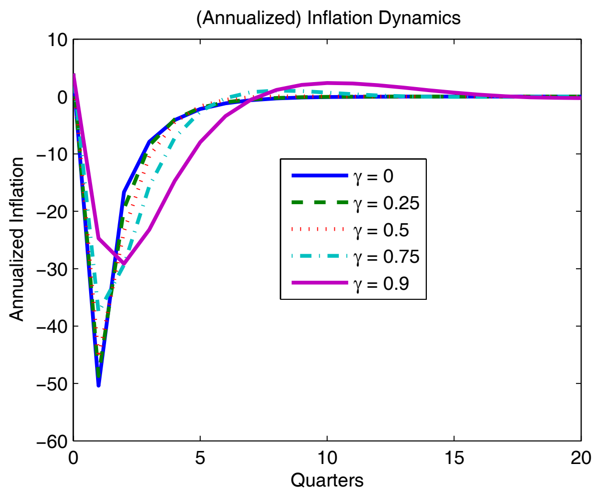


Figure 11: Inflation response after a disinflation from 4% to 0

4.4.5 Returns to Scale

Blanchard and Galí (2007, p. 18) write: "Finally, it is worth noticing that [...] the quantitative results above change significantly if we assume the presence of decreasing returns. Hence, under our alternative calibration with decreasing returns, the loss of output at the outset of the disinflation is multiplied by a factor of 4 relative to the case with no real rigidities (compared with a factor

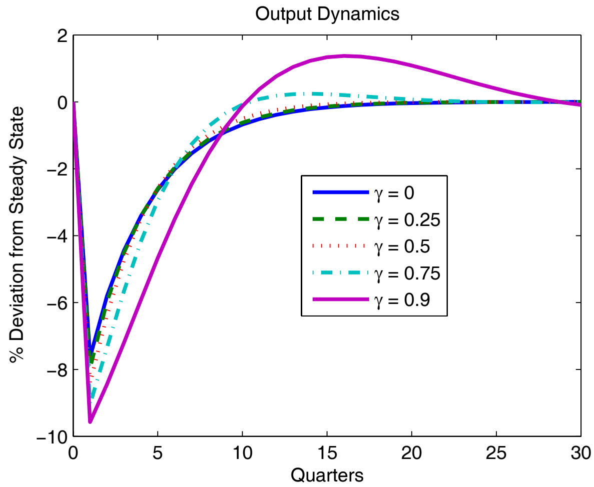


Figure 12: Decreasing returns to scale to labor and the effect of real rigidities

of 10 in the case of constant returns). The smaller initial impact coexists with a larger persistence."

Figure (12) shows indeed that assuming stronger decreasing returns to scale to labor (DRTS) cause: (i) a higher persistence in the output response; (ii) a downward rescaling of the effect of real rigidities. From a quantitative point of view, however, the effects are not of the size described by Blanchard and Galí (2007): actually assuming DRTS makes real rigidities virtually unimportant for the output response to a disinflation.

Finally, it is worth visualizing the different paths of the output response for the Blanchard and Galí (2007) preferred calibration (i.e., $\gamma = 0.9$) under almost constant and DRTS. With DRTS not only persistence, but also the impact effect is larger. Note that simply by differentiating (25) at p. 17 in Blanchard and Galí (2007) with respect to α, it is easy to check that Blanchard and Galí (2007) equations would actually imply the opposite: an increase in α would lower the impact effect of a disinflation.

4.5 Concluding Thoughts

In a stimulating paper Blanchard and Galí (2007) look at disinflations in a standard NK model augmented by the introduction of real wage rigidities. They claim this feature to be crucial for this class of models to explain the cost of disinflation.

In this chapter, we show that, like others in the literature, the analysis in Blanchard and Galí (2007) is flawed because it abstracts from non-linearities, being based on the log-linear formulation of the standard NK model. Indeed,

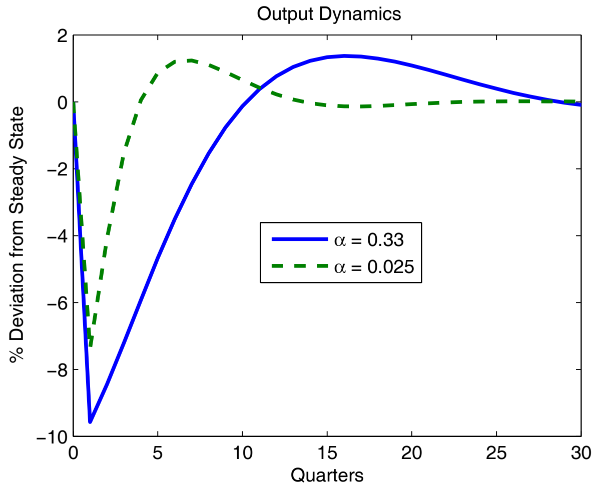


Figure 13: DRTS and ouput response after a disinflation from 4% to 0 $(\gamma = 0.9)$

we show that the results in their Section 4 are inaccurate both qualitatively and quantitatively, once the full microfounded and non-linear model is taken into account.

This chapter sounds a cautionary note with respect to log-linearized model as a tool to analyze disinflation experiments theoretically. More generally, we want to advocate the explicit consideration of the effects of non-linearities, whenever it is necessary and possible.

4.6 Technical Appendix

4.6.1 Firms' Price Setting

$$P_{i,t} = \left(\frac{\varepsilon_p}{\varepsilon_p - 1}\right) \frac{E_t \sum_{j=0}^{\infty} \theta_p^j \Delta_{t,t+j} \left[P_{t+j}^{\varepsilon_p} Y_{t+j} MC_{i,t+j}^{re}\right]}{E_t \sum_{j=0}^{\infty} \theta_p^j \Delta_{t,t+j} \left[P_{t+j}^{\varepsilon_p - 1} Y_{t+j}\right]} \tag{135}$$

This can be rewritten as

$$\frac{P_{i,t}}{P_t} = \left(\frac{\varepsilon_p}{\varepsilon_p - 1}\right) \left(\frac{NU_t}{DN_t}\right) \tag{136}$$

$$NU_t = E_t \sum_{j=0}^{\infty} (\theta_p \beta)^j \, Ut_C \, (t+j) \left[\left(\frac{P_{t+j}}{P_t}\right)^{\varepsilon_p} Y_{t+j} MC_{i,t+j}\right] \tag{137}$$

$$DN_t = E_t \sum_{j=0}^{\infty} (\theta_p \beta)^j \, Ut_C \, (t+j) \left[\left(\frac{P_{t+j}}{P_t}\right)^{\varepsilon_p - 1} Y_{t+j}\right] \tag{138}$$

The denominator can also be written as:

$$DN_t = Ut_C \, (t) \, Y_t + E_t \sum_{j=1}^{\infty} (\theta_p \beta)^j \left[\left(\frac{P_{t+j}}{P_t}\right)^{\varepsilon_p - 1} Ut_C \, (t+j) \, Y_{t+j}\right] \tag{139}$$

Thus:

$$DN_t = Ut_C \, (t) \, Y_t + \theta_p \beta E_t \left(\pi_{t+1}^{\varepsilon_p - 1} DN_{t+1}\right) \tag{140}$$

and

$$NU_t = Ut_C \, (t) \, Y_t MC_{i,t} + \theta_p \beta E_t \left(\pi_{t+1}^{\varepsilon_p} NU_{t+1}\right). \tag{141}$$

4.6.2 Indexation to Long-Run Inflation

Under this assumption, a firm that cannot re-optimize its price updates the price according to this simple rule:

$$P_{i,t} = \bar{\pi}^{\chi} P_{i,t-1} \tag{142}$$

where $\bar{\pi}$ is the steady state inflation level and $\chi \in [0, 1]$ is a parameter that measures the degree of indexation. If $\chi = 1$, there is full indexation, if $\chi = 0$ there is no indexation and the problem is the same one as in the previous case.

The problem of a price-resetting firm then becomes the following

$$\max_{p_t^*(i)} \quad E_t \sum_{j=0}^{\infty} \theta_p^j \Delta_{t,t+j} \left[\frac{P_{i,t}\bar{\pi}^{\chi j}}{P_{t+j}} Y_{i,t+j} - TC_{t+j}^{re} \left(Y_{i,t+j} \right) \right] \tag{143}$$

$$s.t. \quad Y_{i,t+j} = \left[\frac{P_{i,t}\bar{\pi}^{\chi j}}{P_{t+j}} \right]^{-\varepsilon_p} Y_{t+j} \tag{144}$$

and the first order condition is

$$P_{i,t} = \frac{\varepsilon_p}{\varepsilon_p - 1} \frac{E_t \sum_{j=0}^{\infty} \theta_p^j \beta_{t,t+j} \left[P_{t+j}^{\varepsilon_p} Y_{t+j} MC_{i,t+j}^{re} \bar{\pi}^{-\varepsilon_p \chi j} \right]}{E_t \sum_{j=0}^{\infty} \theta_p^j \beta_{t,t+j} \left[P_{t+j}^{\varepsilon_p - 1} Y_{t+j} \bar{\pi}^{(1-\varepsilon_p)\chi j} \right]} \tag{145}$$

This can be rewritten again as

$$\frac{P_{i,t}}{P_t} = \left(\frac{\varepsilon_p}{\varepsilon_p - 1} \right) \left(\frac{NU_t}{DN_t} \right) \tag{146}$$

$$DN_t = E_t \sum_{j=0}^{\infty} \left(\theta_p \beta \right)^j Ut_C \left(t+j \right) \left[\left(\frac{P_{t+j}}{P_t} \right)^{\varepsilon_p} Y_{t+j} MC_{i,t+j}^{re} \bar{\pi}^{-\varepsilon_p \chi j} \right] \tag{147}$$

$$NU_t = E_t \sum_{j=0}^{\infty} \left(\theta_p \beta \right)^j Ut_C \left(t+j \right) \left[\left(\frac{P_{t+j}}{P_t} \right)^{\varepsilon_p - 1} Y_{t+j} \bar{\pi}^{(1-\varepsilon_p)\chi j} \right] \tag{148}$$

Employing similar substitution as above these two equations can be written as

$$NU_t = E_t \sum_{j=0}^{\infty} \left(\theta_p \beta \right)^j Ut_C \left(t+j \right) \left[\left(\frac{P_{t+j}}{P_t} \right)^{\varepsilon_p} Y_{t+j} MC_{i,t+j}^{re} \bar{\pi}^{-\varepsilon_p \chi j} \right] \tag{149}$$

$$NU_t = Ut_C(t) \left[Y_t MC_{i,t}^{re} \right] + \theta_p \beta \bar{\pi}^{-\varepsilon_p \chi} E_t \left(\pi_{t+1}^{\varepsilon_p} NU_{t+1} \right) \tag{150}$$

and similarly

$$DN_t = E_t \sum_{j=0}^{\infty} \left(\theta_p \beta \right)^j Ut_C \left(t+j \right) \left[\left(\frac{P_{t+j}}{P_t} \right)^{\varepsilon_p - 1} Y_{t+j} \bar{\pi}^{(1-\varepsilon_p)\chi j} \right] \tag{151}$$

$$DN_t = Ut_c(t) Y_t + \theta_p \beta \bar{\pi}^{(1-\varepsilon_p)\chi} E_t \left(\pi_{t+1}^{\varepsilon_p - 1} DN_{t+1} \right) \tag{152}$$

The aggregate price level now evolves according to

$$P_t = \left[\int_0^1 {P_{i,t}}^{1-\varepsilon_p} di\right]^{\frac{1}{1-\varepsilon_p}} = \left[\theta_p \overline{\pi}^{(1-\varepsilon_p)\chi} P_{t-1}^{1-\varepsilon_p} + (1-\theta_p){P_{i,t}}^{1-\varepsilon_p}\right]^{\frac{1}{1-\varepsilon_p}} \Rightarrow \tag{153}$$

$$1 = \left[\theta_p \overline{\pi}^{(1-\varepsilon_p)\chi} \pi_t^{\varepsilon_p - 1} + (1-\theta_p)\left(\frac{P_{i,t}}{P_t}\right)^{1-\varepsilon_p}\right]^{\frac{1}{1-\varepsilon_p}}. \tag{154}$$

Aggregation and price dispersion:

$$s_t = \int_0^1 \left[\frac{P_{i,t}}{P_t}\right]^{-\frac{\varepsilon_p}{1-\alpha}} di \tag{155}$$

$$s_t = (1-\theta_p)\left[\frac{P_{i,t}}{P_t}\right]^{-\frac{\varepsilon_p}{1-\alpha}} + \theta_p \left(\frac{\pi_t}{\overline{\pi}^{\chi}}\right)^{\frac{\varepsilon_p}{1-\alpha}} s_{t-1} \tag{156}$$

Under indexation to long-run inflation the following system of equations is simulated:

Equations (104), (105), (106), (115), (150), (152), (154), (121), (122), and (156).

In the presence of a real wage rigidity, equation (105) is replaced by equation (109).

5 The East German Labor Market after Reunification

5.1 Introduction

This chapter[98] offers an explanation why the East German labor market has made disappointing progress since German reunification. The unemployment rate almost doubled from 1991 to 2004 (from around 10% to 20%)[99], despite massive migration flows from East Germany to West Germany. The official figures depict only the tip of the iceberg, since they neglect the big stock of hidden unemployment (e.g. Bonin and Zimmermann, 2000, Fuchs and Weber, 2005). The share of long-term unemployed has climbed from a quarter in 1992 to almost a half in 2004 (e.g. Sachverständigenrat, 2004, p. 315). Since 1997 the East German GDP has grown at rates similar or even lower than those in the West.[100]

This sorry performance may seem puzzling, for East Germans were the envy of their newly-capitalist neighbors. Through reunification, they received well-functioning legal and welfare systems, an orderly privatization process, generous welfare benefits and infrastructure investment - all financed by transfers from West Germany.

At the beginning of the nineties this jump start helped East Germany to have a much smoother transition in terms of macroeconomic stability than its Eastern European neighbors (see Appendix for a comparison to Czech Republic). But after an initial straw fire, spurred by West Germany, the Eastern neighbors started to catch-up or even to overhaul. They are doing much better in terms of their unemployment rates.[101] Slovenia is the first transition country which has a bigger GDP per head than East Germany. Others are probably going to follow soon.

Today, transfers are running at around €80 billion per year[102] (about 4%

[98] A short version of this chapter was published as "The Caring Hand that Cripples: The East German Labor Market after Reunification," with Dennis Snower. American Economic Review, Vol. 96, No. 2, pp. 375-382. Detailed version: IZA Discussion Paper, No. 2066, April 2006.

[99] According to the official statistics of the Bundesagentur für Arbeit (2006) the unemployment rate among dependently employed in East Germany (including Berlin) has risen from 10.2% in 1991 to 20.1% in 2004.

[100] Source: Statistische Ämter des Bundes und der Länder (2005).

[101] The International Labour Organization (2004, p. 27) writes that the average unemployment rate in the transition economies is 9.2%.

[102] Numbers for 2003. Gross transfers (not deducting federal taxes) even amounted to 116 billion Euro (Ragnitz, 2003, p. 2).

of Germany's GDP) with no sign of abating; 50% of them constitutes social assistance, e.g. unemployment and retirement benefits. About one quarter of East German private consumption is paid by West German transfers. When the transfer driven production is deducted, even in East Germany's economically strong regions the GDP per head is only about 55% of the West German level (Lehmann et al., 2005). Never before has a region received such immense support in the move to capitalism; but the fledgling has not thrived. What went wrong?

The answer, we will argue in this chapter, is that the East German labor market is in trouble precisely *because* of the support it has received. This chapter explores the phenomenon of "the helping hand that cripples." We view East Germany as an important case study in the pitfalls to transition, highlighting weaknesses of other European welfare systems.

We argue that the following mistakes were made in East Germany, each disguised as social support.

Bargaining by proxy: Right after reunification, East German wage bargaining was primarily in the hands of *West German* unions and employers, rather than their weak and inexperienced Eastern counterparts (e.g. Sinn, 2002). The Westerners rapidly raised the Eastern wage, in the name of solidarity and equality with the Easterners. In reality, however, Western unions feared migration of workers from East to West and of firms in the opposite direction, resulting in downward pressure on Western wages and employment. Given a low short-run elasticity of labor demand, there was an incentive to raise East German wages.

Unemployment benefits and associated welfare entitlements: The East inherited generous unemployment support through unification. This, along with stringent job security provisions and other labor market regulations, also put upward pressure on wages and kept them high (relative to productivity) even once East Germans began to gain control over their own wages.[103]

The post-unification wage hike led to a sharp fall in East German employment. Thereafter, however, Eastern real wages fell relative to productivity.

[103] Other factors also helped make labor expensive in the East. For instance, the huge *investment subsidies* after reunification naturally raised the price of labor relative to the price of capital. The decision to adopt a *1-to-1 exchange rate* between the East and West German mark after reunification, amounted to a massive appreciation of the EG currency. Yet we will focus on bargaining by proxy, unemployment benefits, job security and regulations, for without them, EG wages could have largely compensated for the investment subsidies and the exchange rate decision.

But the employment rate scarcely rose. Why?

Employment persistence: Through reunification East Germany inherited West German labor legislation, including generous job security provisions that raised firing costs and labor regulations that raised hiring costs. Due to these "caring hand" measures, employment became much more persistent (temporary labor market shocks had more persistent after-effects).

Yet employment persistence cannot tell the whole story. It explains why the employment response was sluggish, but not why the Eastern employment rate hardly rose at all. Moreover, East German industrial labor productivity remains about one quarter beneath that in the West even though capital intensity is higher than in the West (e.g. Klodt, 2000).

We will suggest that these phenomena may have arisen because East German labor force participants fell into "traps," concerning low skills, aging of the workforce, labor-saving capital and skills, capital underutilization, and unemployment arising from the decline of the tradable sector. These traps were all promoted by the "caring hand" of the West.

We maintain that the problems above extend well beyond East Germany; rather, they appear whenever labor market institutions generate substantial labor turnover costs and permit insiders to exert significant market power in wage determination. Bargaining by proxy is widespread: within firms, insiders (whether formally through unions or through informal understandings) often have an influence on the wages of entrants. Employment persistence arises whenever there are costs of adjusting employment, the labor force, or the size of the insider workforces within firms. The traps are well-known to policy makers everywhere, especially in terms of their consequences (e.g. poverty traps, unemployment traps, low-skill traps). The existence of traps constitute an important reason why labor market reforms often need to be deep (large changes in policy instruments) and broad (involving several complementary measures).

In what follows, Section 2 presents a model of wage determination and employment persistence, Section 3 deals with the traps, Section 4 presents our calibration exercises, and Section 5 concludes.

5.2 Wage Determination and Employment Persistence

We present a particularly simple model of the East German labor market, with the following sequence of decisions: first, wages are determined, taking into account their influence on migration and employment; second, migration decisions are made, taking wages as given; and third, firms make their employment decisions, taking wages and migration as given. We start with the last stage.

5.2.1 Employment

Assume constant returns to labor and let a and $\widehat{a}$ be labor productivity in East Germany and West Germany,[104] respectively. (All West German variables are denoted by $\widehat{}$.) There is a random operating cost ξ_t,[105] iid across workers and time, with a mean normalized to zero and a constant cumulative distribution $\Gamma(\xi_t)$. For the wage w, firing cost f per worker (constant), firing rate ϕ, and discount factor δ, an insider generates the following expected profit:[106] $\Pi_t = -\xi_t + \sum_{t=0}^{\infty} \delta^t (1-\phi)^t (a-w) - \delta\phi f \sum_{t=0}^{\infty} \delta^t (1-\phi)^t$.

The insider is fired when $\Pi_t < -f$, so that $\xi_t > (a - w + (1-\delta) f) / (1-\delta(1-\phi))$. Thus the firing rate is given by the following implicit function:[107]

$$\phi = 1 - \Gamma\left(\frac{a - w + (1-\delta) f}{1-\delta(1-\phi)}\right) \tag{157}$$

Given a hiring cost h per worker (a constant), an entrant is hired when $\Pi > h$, so that the hiring rate is

$$\eta = \Gamma\left(\frac{a - w - \delta\phi f}{1-\delta(1-\phi)} - h\right) \tag{158}$$

The change in employment (ΔN_t) is the difference between the hiring from the unemployment pool ($\eta U t_{t-1}$) and the firing from the employment pool (ϕN_{t-1}), where $U t_{t-1}$ and N_{t-1} are the aggregate unemployment and employment levels: $\Delta N_t = \eta U t_{t-1} - \phi N_{t-1}$. Letting ($n_t = N_t/L_t$) be the employment rate and g_t be the labor force growth factor ($g_t = L_t/L_{t-1}$), this implies the following *employment dynamics equation*:

$$n_t = \frac{1}{g_t}\left(\eta + (1-\eta-\phi)\, n_{t-1}\right) \tag{159}$$

and similarly for West Germany.

[104] The capital stock is not modeled endogenously. Changes in wages have a substitution and scale effect. The overall outcome depends on their relative magnitude.

[105] For a detailed description of the sequencing see Appendix.

[106] In what follows, only those variables have time subscripts that, for given parameter values, actually vary through time in our model.

[107] We assume that $(\partial\Gamma/\partial\phi) > -1$, so that a rise in $(a-w)$ or f both reduce the firing rate.

In this context, the massive East German wage hike after reunification reduced the hiring rate η and thereby led to a sharply lower employment rate n_t (due to a downward shift of curve (159). Furthermore, this East German employment collapse became long-lived since reunification raised the degree of employment persistence. Specifically, the reunification-induced increase in job security (raising firing costs) and labor market regulations (raising hiring costs), reduced the hiring and firing rates (η and ϕ) and thereby raised the employment persistence parameter $(1-\eta-\phi)/g_t$, *ceteris paribus*.

5.2.2 Migration

Theoretical Framework: Labor force growth in our model depends only on migration. Assuming for simplicity that household per-period utility is equal to consumption (no disutility of work), migration depends on the difference between the expected present values of income to be earned in East and West.

In equilibrium, an insider's present value is $V_i = w + \delta\left(\left(1-\phi\right)V_i + \phi V_o\right)$, and for an entrant (both in the East) it is $V_o = b + \delta\left(\eta V_i + \left(1-\eta\right)V_o\right)$, which can be solved for V_i and V_o. Assume that East German insiders and outsiders become outsiders in West Germany. Let $\widehat{V}_i, \widehat{V}_o > V_o$, implying migration from East to West.

Workers are heterogeneous in terms of their mobility costs, which are iid across workers and through time. For simplicity, we view the migration cost solely as a congestion-type cost, letting the cost of the marginal migrant be $co\left(mi_{jt}\right)$, $j = i, o$; co', $co" > 0$; where $mi_{j,t} = MI_{j,t}/L_t$, $MI_{j,t}$ is the number of migrants j, and $MI_{i,t} + MI_{o,t} = \Delta L_t$. Setting this cost equal to the gain from migration for the marginal insider and outsider, we obtain the aggregate migration rate:[108]

$$mi = g - 1 = co^{-1}\left(\widehat{V}_o - V_i\right) + co^{-1}\left(\widehat{V}_o - V_o\right). \tag{160}$$

A rise in the East German wage w (*ceteris paribus*) has countervailing effects: it raises the attractiveness of East German jobs, thereby reducing migration from East Germany; it also reduces the hiring rate and raises the firing rate in East Germany, thereby increasing migration. In the calibrated model below, the former effect dominates, so that an East German wage increase reduces migration. A fall in migration, in turn, reduces the growth rate of the

[108] In the long run, we expect some mechanism to come into operation, so that net migration comes to an end (e.g. equalization of East-West income differentials). Since this tendency has been minor since reunification, we leave it out of our current analysis.

West German labor force and thereby increases the West German employment rate (by the West German counterpart of equation (159). In short, a rise in the East German wage leads to a rise in the West German employment rate.

Empirical Evidence: The empirical literature provides evidence in favor of the hypothesis that higher wages have reduced the migration flows from East to West. The wage differential for migrants shows a positive impact on the propensity to migrate (Brücker and Trübswetter, 2004). Burda and Hunt (2001) analyze the effects of the wage level in source and destination states on the actual propensity to migrate. For the beginning of the nineties they conclude that "on balance, high wages in the East reduced emigration" (p. 62), whereas they have difficulties in explaining the rise of the East-West migration in 1998 by the actual wage and unemployment levels. They attribute it to a change of expectations, specifically, the anticipation among East Germans that there will be no complete wage adjustment in the near future.[109]

It is worth noting that the empirical literature does not find a clear-cut relationship between income and migration. For example, Burda (1993), and Burda et al. (1998) present a U- or S-shaped form, which they attribute to the option value of waiting. Observe, however, that this stream of the literature analyzes the effect of *household income* on migration, and thus does not adopt our approach of focusing on differentials in the expected present value of future income streams. We are not aware of any empirical study that analyzes the effect of present value differentials on the propensity to migrate.

An indirect way of assessing the consequences of high wages is to examine how East German wage increases affect the overall East German wage bill. For this purpose, it is necessary to estimate the elasticity of labor demand (under the assumption that, in the presence of substantial East German unemployment, employment decisions are determined by the labor demand). A short-run labor demand elasticity greater than minus one of course implies that the overall wage bill rises in the short run when wages increase. Riphan et al. (1999, p. 27), surveying the empirical literature for Germany as a whole on this issue, find that almost all the estimated labor demand elasticities lie well beneath 1 in absolute terms.[110]

[109] In our calibration model below, we assume perfect foresight over the sample period, and thus expectational swings are captured only insofar as they turn out to be realistic.

[110] Franz and König (1986), Stark and Jänsch (1988), Flaig and Steiner (1989), Kraft (1991), Zimmermann and Bauer (1997), Buslei and Steiner (1999), and Falk and Köbel (2001) all estimate labor demand elasticities that are consonant with our theory. The only outlier is Trabert et al. (1998).

Heitger (2001) or FitzRoy and Funke (1996) estimate effects of wages on employment for East Germany that are usually either greater than -1 or not significantly different from zero, which is consonant with our assumption that an East German wage hike raises East German income.[111]

5.2.3 Wage Determination

Theoretical Framework: We consider two types of wage negotiations: (i) "self-sufficient bargaining", in which the bargaining parties determine their own wages (the standard wage bargaining framework) and (ii) "bargaining by proxy". We represent West German wage bargaining as self-sufficient. We view East German wages after unification as reflecting both types of wage negotiations, with bargaining by proxy gradually giving way to self-sufficient bargaining with the passage of time.

Under self-sufficient bargaining, let the wage be the outcome of a bargain between each insider and his firm. The wage is renegotiated in each period. Under bargaining agreement, the insider receives the wage w, and the firm receives the expected profit $(a-w)$ in each period. Under disagreement, the insider's fallback income is b, assumed equal to the unemployment benefit, and the firm's fallback profit is $-f$, i.e. during disagreement the insider imposes the maximal cost on the firm (e.g. through strike, work-to-rule, sabotage) short of inducing dismissal. Assuming that disagreement in the current period does not affect future returns, the insider's surplus is $w-b$ and the firm's surplus is $a-w+f$.[112] The negotiated wage maximizes the Nash product $(w-b)^{\mu}(a-w+f)^{1-\mu}$, where μ represents the bargaining strength of the insider relative to the firm (assumed equal in East Germany and West Germany). Similarly for the West German wage. Thus the negotiated wages are

[111] One exception in Fitzroy and Funke's (1998) paper is the estimated short-run elasticity for low-skilled in East German manufacturing, which is smaller than -1 (-1.26), but statistically not different thereof at a 95% confidence level.

[112] Specifically, the expected present value of returns under agreement are $V_{i,t}=w_t+\delta\left(\left(1-\phi_{t+1}\right)V_{i,t+1}+\phi_{t+1}V_{o,t+1}\right)$ and $\widetilde{\Pi}_t=(a_t-w_t)+\delta\left(\left(1-\phi_{t+1}\right)\widetilde{\Pi}_{t+1}-\phi_{t+1}f_{t+1}\right)$, for the insider and the firm, respectively. (Since the wage is renegotiated in each period, the present value in period t is independent of the present value in period $t+1$.) Since disagreement in the current period does not affect future returns, the present value of returns under disagreement are $V'_{i,t}=b_t+\delta\left(\left(1-\phi_{t+1}\right)V_{i,t+1}+\phi_{t+1}V_{o,t+1}\right)$ and $\widetilde{\Pi}'_t=-f_t+\delta\left(\left(1-\phi_{t+1}\right)\widetilde{\Pi}_{t+1}-\phi_{t+1}f_{t+1}\right)$, for the insider and the firm, respectively. Thus the insider's surplus is $V_{i,t}-V'_{i,t}=w_t-b_t=w-b$ and the firm's surplus is $\widetilde{\Pi}_t-\widetilde{\Pi}'_t=a_t-w_t+f_t=a-w+f$.

$$w = (1-\mu)\, b + \mu\, (a+f)\,, \quad \hat{w} = (1-\mu)\, \hat{b} + \mu \left(\hat{a} + \widehat{f}\right) \tag{161}$$

We conceive of bargaining by proxy as a broad-based process, supported by public institutions, involving *all* West German firms and workers (not just the insiders). The bargaining parties are concerned with the East German wage because, as noted, it positively affects the West German employment rate.

A rise in the West German employment rate, in turn, raises the West German workers' payoff and reduces the West German firms' payoff, along the following lines. Let the average incomes of West German outsiders and insiders (per period) be $\hat{y}_o = \hat{\eta}\hat{w} + (1-\hat{\eta})\,\hat{b}$ and $\hat{y}_i = \left(1-\hat{\phi}\right)\hat{w} + \hat{\phi}\hat{b}$, respectively. Then the average West German worker's bargaining surplus per period $t+j$ is $\hat{y}_o\,(1-\hat{n}_{t+j}) + \hat{y}_i\hat{n}_{t+j} - \widetilde{y}$, where $\widetilde{y}$ is the fallback income under bargaining disagreement (exogenously given). This surplus rises with the employment rate. For simplicity, let $\hat{y}_o = \widetilde{y}$, so that the West German worker's per-period surplus reduces to $(\hat{y}_i - \hat{y}_o)\,\hat{n}_{t+j}$. Thus the present value of the worker's surplus is

$$\Lambda_w = \left((\hat{y}_i - \hat{y}_o) \sum_{j=0}^{\infty} \delta^j \hat{n}_{t+j} \right). \tag{162}$$

Under bargaining agreement, the average firm receives $\widehat{a} - \widehat{w} - \widehat{f}\widehat{\phi}\widehat{n} - \widehat{h}\widehat{\eta}\,(1-\widehat{n})$ per period; under disagreement, it receives $-f$. Thus its surplus per period is $\widehat{o}_a - \widehat{o}_n\hat{n}_t$, where $\widehat{o}_a = \widehat{a} - \widehat{w} - \widehat{h}\widehat{\eta} + \widehat{f}$ (autonomous surplus) and $\widehat{o}_n = \widehat{f}\widehat{\phi} - \widehat{h}\widehat{\eta}$ (induced surplus). We assume that $\widehat{o}_n > 0$, so that, plausibly, the firm's surplus falls with the employment rate.[113] The present value of the firm's surplus is

$$\Lambda_f = \sum_{j=0}^{\infty} \delta^t \left(\widehat{o}_a - \widehat{o}_n \hat{n}_{t+j}\right). \tag{163}$$

Thus bargaining by proxy can be expressed in terms of a bargain over the West German employment rate $\hat{n}_t$. The Nash product is $(\Lambda_w)^{\mu}\,(\Lambda_f)^{1-\mu}$, to be maximized with respect to $\hat{n}_t$. Since the present values Λ_w and Λ_f are time-invariant, the bargaining solution is time-invariant as well: $\hat{n}_t = \hat{n}$. Solving the Nash bargaining problem, we obtain the following target West German

[113]In practice, there are of course many other reasons why the firms' surplus falls as the employment rate rises, e.g. firms' costs of searching for workers rise, and firms' fall-back positions deteriorate (since insiders are likely to be more aggressive during bargaining disagreement).

employment rate:

$$\widehat{n} = \mu \frac{\widehat{o}_a}{\widehat{o}_n} \tag{164}$$

The West German bargainers achieve this target employment rate by setting the East German wage w.

The greater the workers' bargaining strength μ, the greater is the West German target employment rate and the higher the East German wage will be set. The lower the migration costs co, the higher will be the East German wage corresponding to a given West German target employment rate. In this way, our model shows why the East German labor market suffered on account of purported "advantages" of the East Germans - the ability to migrate to the wealthy West and increased bargaining strength bestowed by their Western counterparts.

Empirical Evidence: There is a large body of evidence, largely anecdotal, documenting the dominant role of West Germans in East Germany's wage bargaining. For example, Schröder (2000, p. 9 f.) examines the role of Germany's largest industrial union IG Metall[114] and its counterpart employers' association: "Im Gewerkschaftsbereich bestand für einige Monate eine sichtlich belastende Konkurrenzsituation zwischen der bundesdeutschen IG Metall und der IG Metall/DDR. Mit der Ankündigung der Währungsunion und der Präferenz für das Beitrittsmodell ging die Federführung auf die westdeutsche Seite über. Für Arbeitgeberverbände und IG Metall ergaben sich daraus unterschiedliche organisationspolitische Strategien. Auf Arbeitgeberseite wurden zwar die ostdeutschen Funktionäre formal bestätigt; real wurde jedoch für einen nicht weiter definierten Zeitraum ein paternalistisches Lehrer-Schüler-Verhältnis installiert, mit dem die faktische tarifpolitische Entscheidungskompetenz bei den westdeutschen Verbänden lag. Während die ostdeutschen Arbeitgeberverbände integriert wurden, musste sich die IG Metall/DDR auflösen. Deren Führungselite wurde durch eine westdeutsche Funktionärsschicht ersetzt, die den Aufbau nach westdeutschen Vorgaben und Erfahrungen gestalten sollte." (authors' translation: "In the union sector there was costly competition between the West German metal working union, IG Metall, and its counterpart from East Germany for a couple of months. With the announcement of the monetary union and the preference for accession, the decision-making was handed over to the West German side. This gave rise to different organizational strategies for employers' associations and the union IG Metall. On

[114] Responsible for the metal-working industry.

Union Members / Employed	East Germany	West Germany
Year 1992	39.7%	28.7%
Year 1996	26.7%	26.6%
Year 2002	20.4%	23.8%

Table 2: Union membership

the employers' side the East German officials were in fact confirmed officially. But in reality there was a paternalistic teacher-pupil relationship for an indefinite time period, which gave the de facto decision making power to the West German associations. While East German employers' associations became integrated into the negotiation process, the East German metal working union had to disband. Its leadership elite was replaced by a West German shift of officials, which were to pursue East German reconstruction according to West German guidelines.") This view is e.g. confirmed by Fitzroy and Funke (1996, p. 460): "Initial collective bargaining was conducted between west German unions (in the absence of legitimate union representatives in East Germany) and managers of the existing large state-owned enterprises. As is well-known, a succession of wage increases to the western level was agreed in the initial round of negotiation." The influence of the unions on East German wage negotiations was widespread. For instance, Burda and Funke (1993, p. 541) write that the "unions were recognized by eastern German employers as the *de facto* negotiating partner in collective bargaining and were thereby able to conclude wage agreements in almost every industrial sector and many of the service branches. The adoption of west German labor laws by the GDR [German Democratic Republic], including those governing severance, made this organizational campaign easier." We take these and many other observations as evidence in favor of our "bargaining by proxy" hypothesis.

Furthermore, our analysis suggests East German wage negotiations are emancipating themselves from West German influence. This is of course a gradual process. Supporting evidence is that the membership rate of East German unions halved from 1992 to 2002, while the reduction in West Germany during the same time period was more modest (see table (2)[115]).

Moreover, in 2000, three quarters[116] of East German companies were not tied to a collective bargaining agreement (see e.g. Kohaut and Schnabel, 2003), whereas this number was as low as 25% in 1993.

[115]Source: Schnabel (2005, p. 185)

[116]The rate was about 50% for West Germany.

There were many signs of resistance to West German influence on East German wage bargaining. For example, in 1993 the employer's association in the metal working industry dropped a collective bargaining agreement that would have claimed wage increases of 26% (see Czada, 1998). In 2003 Germans witnessed an important symbolical event which signal how far the emancipation from the West had progressed. The powerful trade union IG Metall tried to introduce the 35-hour week in East Germany, which would have pushed regular working time down to the same level as in West Germany. To achieve enough manpower for the strike, the trade union IG Metall had to bring supporters from West Germany to the East, and these supports attempted to prevent East German workers from entering their firms. In the end, the resistance of the East German work force and employers to this "helping hand" became overwhelming and the 35-hour week was not implemented in the East.

East German labor cost data is also suggestive. In figure (14)[117], we compare actual East German labor costs to the values predicted by our self-sufficient bargaining model (for details of the calculation see Section 4 and Appendix). Note that the relative difference between the actual and predicted numbers has fallen steadily. We would interpret a ratio of 1 as East Germans bargaining for their wages entirely self-sufficiently. Our model suggests that West Germans still have a hand in the East German bargaining process, although the influence has gone down significantly.

5.2.4 The East German Labor Market Equilibrium

Theoretical Framework: The East German labor market equilibria are pictured in Fig. 1. The initial employment dynamics line E_0E_0' (corresponding to equation (159), with its long-run equilibrium point A) is hypothetical: it illustrates East German employment in the absence of the "caring hand". Line E_1E_1' depicts employment in the immediate aftermath of reunification, reflecting the influence of high wages due to bargaining by proxy and increased employment persistence (E_1E_1' is steeper than E_0E_0'). The employment persistence implies that the wage hike dampens employment gradually (moving from point A to B along the dotted line), consonant with the fall of the East German employment rate in the first part of the 1990s. Finally, E_2E_2' describes employment once East Germans will gain direct control over their wages, so that East German wages fall somewhat relative to productivity. E_2E_2' lies

[117]Numbers for the five new "Länder," excluding Berlin. Source: Statistische Ämter des Bundes und der Länder (2005), own calculations.

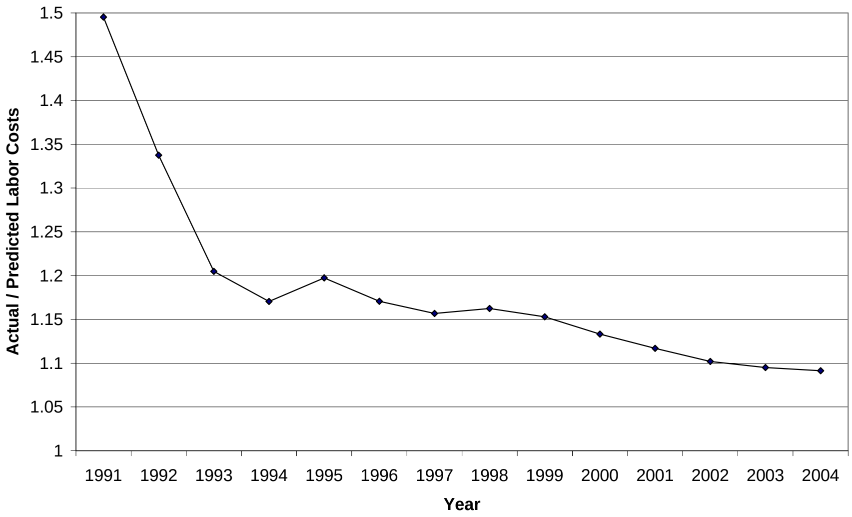


Figure 14: Actual labor costs divided by the predicted labor costs under self-sufficient bargaining

well beneath E_0E_0' on account of generous unemployment benefits and firing costs, keeping wages high. Thus the employment rate rises somewhat, but then remains at a high level (at point C).

Empirical Evidence: East Germany inherited the West German job security legislation with the social and monetary union in 1990. The empirical literature shows that the German (or continental European) labor markets show greater persistence than their Anglo-Saxon counterparts (see e.g. Schmidt, 1999). Fitzroy and Funke (1996) find a higher persistence for the labor demand for skilled and medium skilled labor in East Germany than in West Germany, whereas the opposite is the case for low-skilled labor (0.77 (0.34) for skilled workers in East Germany (West Germany), 0.73 (0.37) for semi-skilled and 0.48 (0.68) for low skilled).

5.3 Traps

5.3.1 Theory

While the model helps explain why the East German employment rate fell gradually in the aftermath of unification, it does not shed light on East Germany's stagnating employment rates. For this purpose, we consider the following labor market "traps":

The low-skill trap: Due to generous unemployment benefits, associated

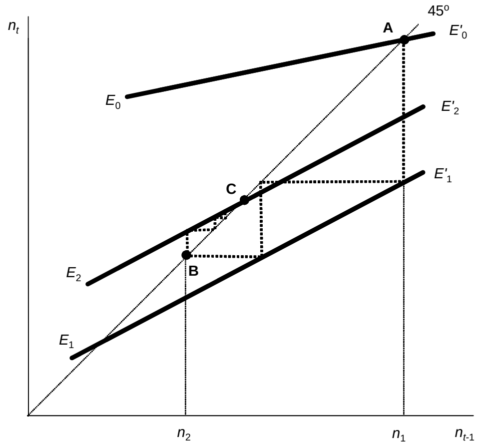


Figure 15: East German employment

welfare entitlements, and job security provisions, wages relative to productivity remained particularly high for East German unskilled workers, who thus became especially unemployment-prone. Without jobs, they could not get on-the-job training and become integrated in the workforce, thus falling into a low-skill unemployment trap.

The aging trap: Since the younger workers have a longer time horizon over which they earn wage income, to be set against the fixed cost of migrating, the younger East Germans have had a greater incentive to migrate to the West, where expected income is higher. This incentive was reinforced by the post-unification wage hike: since the elasticity of labor demand is smaller in the short run than in the long run, the wage hike raised wage income more in the short run, i.e. the time span relevant to older workers. Insofar as older workers are less flexible and versatile than their younger counterparts, this may lead to less flexible and versatile capital accumulation. Thereby the East became susceptible to an "aging trap" in which old skills and old capital dampened labor productivity and thus labor demand.

The labor-saving trap: Due to the post-unification wage hike and investment subsidies, it became profitable for firms to invest in labor-saving physical capital. Once this capital was in place, it was of course more difficult to find jobs for East Germany's unemployed. Investment in labor-saving capital raised incentives for workers to acquire the associated "labor-saving labor" skills. The resulting equilibrium, "labor-saving capital-skills trap," economizes on labor, despite high unemployment.

The "wrong" capital-skills trap: The vast investment subsidies in East

Germany generated capital that propped up uncompetitive enterprises and was designed to prevent layoffs in declining industries. Firms had relatively little incentive to avoid underutilization of such capital. This phenomenon provides an explanation for the puzzling phenomenon that labor productivity is generally lower in the East than West, even though capital intensity is comparable or higher. We hypothesize that the "wrong capital" is complementary with "wrong skills", which also tend to be underutilized. The resulting trap helps keep East Germans unemployment-prone and dependent on hand-outs from the West.

The nontradable trap: The massive subsidies from West Germany triggered a rapid rise of product demand in East Germany. Thus the prices of nontradables rose, while tradable prices remained perforce unchanged (while "imports" of tradables from West to East rose). This, combined with wage compression between East and West (due to bargaining by proxy, uniformly generous unemployment benefits and job security provisions), caused *real* producer wages to rise much faster in the tradable than the nontradable sector. The resulting reallocation of labor towards the nontradable sector led to higher unemployment in the transition. Some of this unemployment persisted since retraining takes time and many unemployed workers remained jobless due to generous unemployment benefits, lack of on-the-job training, and retraining costs.

To begin with, we consider a particularly simple way of incorporating them in our previous analysis. Divide the labor market into an "employment creating" sector (EC) and an "employment destroying" sector (ED). In the "low-skill trap," skilled labor (with a relatively high employment rate) is in EC, whereas low-skilled or unemployed labor is in ED. In the "aging trap," EC employs young labor and flexible capital (with expanding labor demand) and ED employs old labor and traditional capital (with stagnant labor demand). In the "labor-saving trap," EC uses labor-using skills whereas ED uses labor-saving skills. In the "wrong capital-skills trap," EC employs competitive capital and skills, whereas in ED they are defensive.

We now amend the model above by supposing that EC-workers have higher productivity than ED-workers, but that workers' wages are compressed due to unemployment benefits, firing costs, etc. Then EC-workers are more profitable and thus have higher hiring rates and lower firing rates than ED-workers ($\eta_{EC} > \eta_{ED}$, $\phi_{EC} < \phi_{ED}$). Suppose that firms give preference to EC-workers, employing ED-workers only once EC-workers are not available. Then the

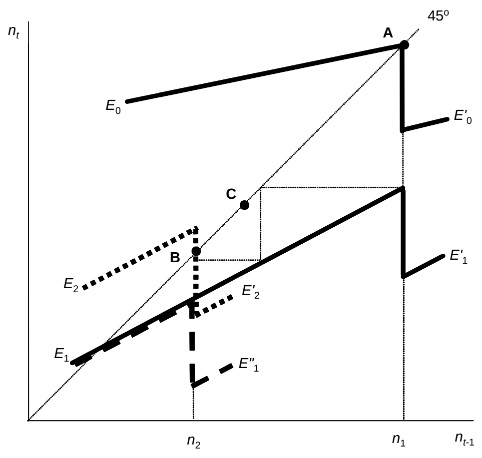


Figure 16: Traps: a simple depiction

employment dynamics curve has a kink at the initial equilibrium point A, as illustrated by the curve $E_0E_0^{'}$ in Fig. 2.[118]

In this context, the post-unification wage hike shifts the kinked curve downward from $E_0E_0^{'}$ to $E_1E_1^{'}$ in the figure. Thus employment falls from n_1 to n_2 (over two periods in the figure). Then the newly unemployed workers $n_2 - n_1$ lose their EC-skills. So the number of EC-workers shrinks and the kink moves leftward to n_2, so that the employment dynamics curve becomes $E_1E_1^{"}$.

Finally, suppose that after two periods, the wage falls back partially, as East Germany gains control over its wage bargaining, so that the employment dynamics curve shifts to $E_2E_2^{'}$. Provided that this upward shift is smaller than the size of the kink, then the equilibrium employment rate remains at n_2, point B (rather than point C, the final equilibrium in Fig. 1): the labor market is in a "trap."

5.3.2 Empirical Evidence

Figure (17) shows that the number of employees in East Germany[119] has fallen enormously since 1990. The tendency is even more pronounced for the industry or the tradable sector in general.

The East German competitive position has been affected dramatically by

[118] The figure assumes, for simplicity, that $\Gamma" = 0$, so that $\partial\eta/\partial a = -\partial\phi/\partial a$, and thus the employment persistence parameter is the same for ED- and EC-workers.

[119] Excluding Berlin. For the development we use the numbers from Statistische Ämter des Bundes und der Länder (2005) from 1991 to 2004. The percentage change from 1990 to 1991 is calculated by using the number of dependent employed people from DIW (1993, p. 256) and DIW (1994, p. 731).

Figure 17: Trapped!

the 1:1 exchange rate adoption and bargaining by proxy. Sinn (2002, p. 118) writes that labor costs were only 7% of the West German level before unification. The ratio has reached about 50% in 1991.[120] Bargaining by proxy has strengthened this development. Werner Smolny (2003) shows that nominal labor costs where increasing by about a quarter from 1990 to 1991, while the labor productivity was falling slightly.

Figure (18)[121] illustrates an important puzzle: although the labor cost normalized by productivity have almost steadily fallen since 1991, the East German employment rate has shown no substantial sign of improvement since 1992. The initial labor cost shock had extremely long after-effects, which cannot be entirely explained by labor market persistence. This provides support for the existence of labor market traps.

We provide empirical evidence for consequences of the different traps, explained in the theoretical section:

The low-skill trap: The unemployment rate among people without qualification in East Germany jumped from around 30% in 1991 to more than a half at the end of the nineties (DIW Berlin et al., 2002, p. 342).

The aging trap: The empirical literature provides support that young

[120] Own calculations. We divided the labor cost per employee in East Germany by the number in West Germany (excluding Berlin entirely). Source: Statistische Ämter des Bundes und der Länder (2005).

[121] All numbers for East Germany without Berlin. The employment rate is defined as (1-official unemployment rate), excluding self-employed. Source: Statistische Ämter des Bundes und der Länder (2005) and Bundesagentur für Arbeit (2006).

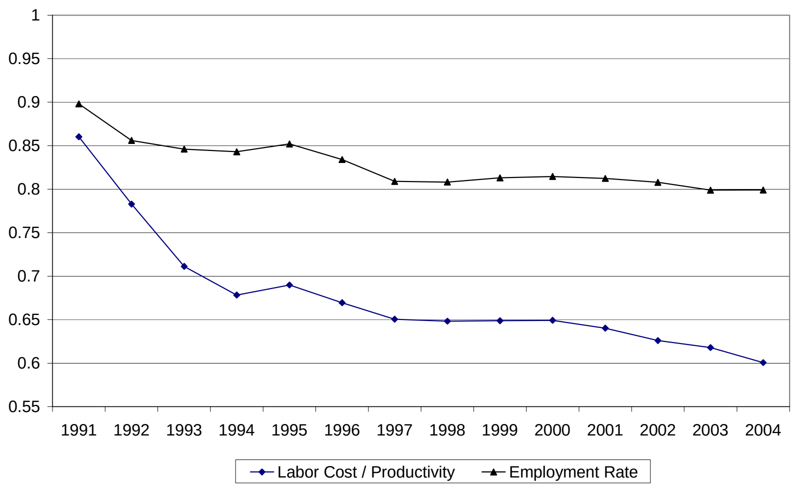


Figure 18: East German labor cost normalized by productivity and the employment rate

people have a higher propensity to migrate (see e.g. Burda, 1993, Burda et al., 1998, Büchel and Schwarze, 1994, Brücker and Trübswetter, 2004). Burda and Hunt (2001) and Hunt (2000) write that movers are on average eleven to fifteen years younger than stayers.

Further evidence is provided by the Institut für Arbeitsmarkt- und Berufsforschung (2005), which predicts that the potential labor force[122] in East Germany will fall from 10 million today to about 4.5 million people in 2050, whereas the drop in West Germany will be more moderate (from 40 to 30 million people).[123]

The labor-saving trap: There is evidence that high wages, coupled with investment subsidies, channeled investment flows heavily into labor saving equipment. This tendency is clearly visible in the manufacturing sector. Gerling (2002) shows that investment into capital intensive sectors had a much larger share in East Germany than in West Germany, whereas the opposite was the case for skilled-labor-intensive sectors.

Table (4) shows that the capital intensities (defined as capital stock divided by the number of employees) in the industry are bigger in East Germany than in West Germany. This phenomenon is even more pronounced when excluding

[122] Defined as number of people in the age group from 15 to 64.

[123] Only a small part of the stronger reduction in East Germany can be explained by the inner German migration. A bigger proportion is due to a more pronounced immigration of foreigners to West Germany (and a lower birth rate in East Germany). We conclude that better long run perspectives render West Germany more attractive.

Sectors[124]	East Germany	West Germany
Capital-intensive	60%	45%
Skilled-Labor-intensive	26%	39%
Unskilled-Labor-intensive	14%	16%

Table 3: Sectoral investment

Sectors[125]	East Germany	West Germany
Capital-intensive	60%	45%
Skilled-Labor-intensive	26%	39%
Unskilled-Labor-intensive	14%	16%

Table 4: Industrial capital intensities

the construction sector (see e.g. Sachverständigenrat, 2004, p. 311).

The "wrong" capital-skills trap: Sinn (1995) argues that the enormous investment subsidies have created a negative cost of capital in East Germany. Thus, capital was not only a factor of production, but also an economic good. Even if the cost of capital was negative in some cases, on average profitable projects were chosen. Nevertheless, the return on capital in East Germany was significantly lower in East Germany than in West Germany during the nineties. Quehenberger (2000, p. 127) estimates that on average it was 5% (15%) from 1991 to 1998 in East (West) Germany and 8% (16%) from 1995 to 1998.

Besides generous investment subsidies there are many other institutional reasons for the creation of "wrong" capital: Sinn (1995) writes e.g. that generous depreciation rules were not helpful for founders of new firms, since they usually do not have any other substantial sources of income, which they could use to write-off their losses. Furthermore, much of the East German investment was not flowing into productive assets. Instead it was channeled into private building activity, stimulated by high wages (causing a boost in demand for rental housing) and the investment subsidies (ensuring low production costs), see e.g. Sinn (1995).

The nontradable trap: While prices in the service sector (which contains a big part of the non-tradable sector) have risen by almost 50% from 1991 to 2001, the price increase in the manufacturing sector (excluding construction) was only 13%.[126] Manufacturing comprises a much smaller share of total employment in East Germany than in West Germany or in the Eastern European

[126] Source: Statistisches Bundesamt.

transition countries (see e.g. Quehenberger, 2000, p. 131, and Statistische Ämter des Bundes und der Länder, 2005).

5.4 Calibration

5.4.1 Employment, Hiring and Firing Rates

We now calibrate the model of Section 2 to provide a rough picture of how, quantitatively, various elements of the "caring hand" can influence East German employment. We begin by predicting the East German employment path, based on our employment dynamics function (159), the hiring rate (226), and the firing rate (225), as well as actual labor costs, productivity, firing costs, and unemployment benefits from 1991 to 2004. (Source: Statistische Ämter des Bundes und der Länder, 2005). Real productivity (a, gross value added per worker) in 2004 was about €36,000 and real wages (w, measured as real labor costs) were about €22,000. (All estimates are divided by the German GDP deflator, base year 1991.)

We interpret actual labor costs as embodying the outcome of the combination of wage bargaining forms - bargaining by proxy and self-sufficient bargaining - that have occurred in East Germany. Thus our predicted employment path is viewed as the outcome of this bargaining combination. Discrepancies between our predictions and the actual employment time series we then interpret a consonant with the existence of traps, providing indirect evidence of the cumulative size of these traps.

To derive the hiring and firing rates, we begin by considering a modified form of the firm's profit function:

$$\Pi_t = -\zeta^t \xi + a_t - w_t - \phi_{t+1} \delta f_{t+1} + \left(1 - \phi_{t+1}\right) \delta E_t \left[\Pi_{t+1}\right] \tag{165}$$

where we now explicitly take productivity growth into account. We divide time into the sample period (1991-2004) and post-2004 (the "long run"). The operating cost ξ is assumed to grow at 2 percent per annum over both subperiods ($\zeta = 1.02$). We use the actual productivity and wage numbers from 1991 to 2004 and we assume that in the long-run the productivity and all real costs (the wage, the hiring and firing costs, and the operating cost ξ) all grow at the same rate.

In the current period t, the profit is $\left(-\zeta^t \xi + a_t - w_t\right)$. With probability ϕ_{t+1} the worker is fired at the beginning of the subsequent period and the firm has to pay the firing costs f_{t+1}, which are discounted (δ) at rate 3%.[127] With probability $(1-\phi_{t+1})$ the worker is retained and thus the firm earns the expected profit $E_t[\Pi_{t+1}]$.

Firing costs (f_t) are set to 60% of labor costs.[128] We set the hiring costs (h_t) to 10% of labor costs (see Chen and Funke, 2003). The replacement ratio (of unemployment benefits to wages) is set at 60%.[129] In practice, after being fired unemployment benefits generally amount to 60%[130] of the last net income during a first stage.[131]

In this context, we also derive a time path of wages under self-sufficient bargaining. For this purpose, we first derive the annual West German bargaining strength parameter μ_t for each year from the wage equation (161), using annual West German data on $\widehat{w}_t$, $\widehat{b}_t$, $\widehat{a}_t$, and $\widehat{f}_t$; then we assume the same μ_t for East Germany, and derive the East German wage w_t, using annual East German data on b_t, a_t, and f_t.

The firm, knowing the current period's operating costs, fires a worker in period t if $\Pi_t < -f_t$ and it hires if $\Pi_t > h_t$. Thus, we obtain the following two implicit functions:

$$\phi_t = 1 - \Gamma\left(\begin{array}{c} \frac{1}{\zeta^t}(a_t - w_t) + \frac{1}{\zeta^t} f_t - \\ \frac{1}{\zeta^t}\delta\phi_{t+1} f_{t+1} + \frac{1}{\zeta^t}\delta\left(1-\phi_{t+1}\right) E_t\left[\Pi_{t+1}\right] \end{array}\right), \qquad (166)$$

and

$$\eta_t = \Gamma\left(\begin{array}{c} \frac{1}{\zeta^t}(a_t - w_t) - \frac{1}{\zeta^t} h_t - \\ \frac{1}{\zeta^t}\delta\phi_{t+1} f_{t+1} + \frac{1}{\zeta^t}\delta\left(1-\phi_{t+1}\right) E_t\left[\Pi_{t+1}\right] \end{array}\right). \qquad (167)$$

We linearize the firing and hiring rates (for technical details, see Appendix)

[127] This is the average real interest rate over the whole observation period, calculated as the yearly money market interest rate minus the inflation rate (using the GDP deflator). Source: International Financial Statistics, International Monetary Fund.

[128] The numbers are similar to evidence from Grund (2006) who writes that the severance payment for collectively dismissed workers in Germany is 8500 Euro, while it is 7000 Euro for individidually dismissed person. Tenure and the wage level are the most important determinants.

[129] In 2002 the net replacement ratio of a person (without children) with the average production worker's salary was between 54 and 85% (depending on the family status) according to the OECD (2004, p. 95).

[130] 67% with children.

[131] The German unemployment benefit system differentiates between two stages. Roughly speaking, everyone who was at least employed (and insured in the social security system) for twelve months during the last three years is in a first stage eligible for "Arbeitslosengeld I" (usually for half a year to a year, with an exception for older workers). In the second stage unemployed can obtain "Arbeitslosengeld II" (lower level of benefits), but have to prove their neediness.

with a first order Taylor expansion and obtain:

$$\begin{aligned}\phi_t &= \phi_0 - \frac{1}{\zeta^t}\Gamma'_0\left[(a_t - w_t) - (a_{t,0} - w_{t,0})\right] \\ &\quad - \frac{1}{\zeta^t}\Gamma'_0\left[(f_t - f_{t,0})\right] + \frac{1}{\zeta^t}\delta\phi_0\Gamma'_0\left(f_{t+1} - f_{t+1,0}\right) \\ &\quad - \delta\frac{1}{\zeta^t}\left(1-\phi_0\right)\Gamma'_0\left(E_t\left[\Pi_{t+1}\right] - E_{t,0}\left[\Pi_{t+1}\right]\right)\end{aligned} \tag{168}$$

and

$$\begin{aligned}\eta_t &= \eta_0 + \frac{1}{\zeta^t}\Gamma'_0\left[(a_t - w_t) - (a_{t,0} - w_{t,0})\right] \\ &\quad - \frac{1}{\zeta^t}\Gamma'_0\left(h_t - h_{t,0}\right) - \frac{1}{\zeta^t}\delta\phi_0\Gamma'_0\left(f_{t+1} - f_{t+1,0}\right) \\ &\quad + \left(1-\phi_0\right)\frac{1}{\zeta^t}\delta\Gamma'_0\left(E_t\left[\Pi_{t+1}\right] - E_{t,0}\left[\Pi_{t+1}\right]\right),\end{aligned} \tag{169}$$

where variables with a subscript $_0$ are at the reference point, around which we linearize. We choose the year 2004 for self-sufficient bargaining to be the reference point for our first order Taylor expansion. Thus, $E_{t,0}\left[\Pi_{t+1}\right]$ would be the expected future profit in period t if all variables trended along a 2% through the anchor point in 2004.

Since we assume that the productivity, the wage, and hiring and firing costs, and operating costs (all in real terms) grow at 2% in the long-run, hiring and firing rates are constant in the long-run. From 1991 to 2004, firing and hiring rates would not change if a, w, f, and X would all grow along the 2%. From the previous firing and hiring rate equations, it thus follows that $E_{t-1,0}\left[\Pi_t\right] = \frac{1}{\zeta}E_{t,0}\left[\Pi_{t+1}\right]$.[132]

We let our predicted hiring and firing rates, based on the actual data,[133] be $\eta_{2004} = 0.57$ and $\phi_{2004} = 0.125$ in 2004, respectively. Furthermore, we assume that the predicted wage path converges to the self-sufficient (SS) bargaining wage path within ten years.[134] In other words, the hiring and firing rates for

[132] The same is true for $(a_{t,0} - w_{t,0})$, $f_{t,0}$, and $h_{t,0}$.

[133] The estimated average risk of unemployment given employment is about 0.08 for West Germany (Wilke, 2005). Under a steady state unemployment rate of 10% the firing rate of 8% corresponds to a hiring rate of 72% in our model. The duration of unemployment was 35 weeks in West Germany and 44 weeks in East Germany in 2004 (Statistisches Bundesamt, 2005). Thus we set the hiring rate to 57% in East Germany. Consistent with a steady state unemployment rate of 18%, the firing rate is set to 12.5%.

[134] The wages under the prediction are linearly adjusted to the self-sufficient value in 2014.

self-sufficient bargaining in 2004 are the same as the predicted ones in 2014. Since we do not know the hiring and firing rate under self-sufficient bargaining in 2004 (anchor point), we set the values $\eta_{2004,SS}$ and $\phi_{2004,SS}$ in such a way that we obtain the expected values (η_{2004} and ϕ_{2004}) for the prediction. All previous values are calculated recursively, based on the linearized model, under the assumption of perfect foresight over the entire sample period.

5.4.2 Migration

We endogenize migration by regressing the East German labor market growth due to migration on the derived present value differentials[135] of incomes between East and West, and use the estimated coefficients for predictions in the policy exercises. In particular, we proceed along the following lines.

The East German workforce (employed plus unemployed people) is about 50% of the population.[136] To generate the actual effect of migration on the workforce (mi_t) we multiply the actual number of migrants by 0.5 and divide it by the workforce.

For the calibration we once again modify equation (160) to take account of productivity growth. Specifically, we assume that the migration costs of the marginal migrant $co\,(mi_{jt})$, $j = i, o$ grow at the same rate as productivity and all the firm's costs in the long run (viz., 2 percent).[137] Thus migration is $mi_{j,t} = co^{-1}\left(\frac{K_j}{\zeta^t}\right)$, so that the migration function becomes

$$mi_t = co^{-1}\left(\frac{\widehat{V}_{o,t} - V_{i,t}}{\zeta^t}\right) + co^{-1}\left(\frac{\widehat{V}_{o,t} - V_{o,t}}{\zeta^t}\right). \tag{170}$$

Next, we estimate the equation $mi_t = \beta_1 + \beta_2\left[\left(2\widehat{V}_{o,t} - V_{i,t} - V_{o,t}\right)/\zeta^t\right]$, through ordinary least squares. We use the estimated coefficients (denoted by the tilde ($\tilde{}$) $\tilde{\beta}_1$ and $\tilde{\beta}_2$ to obtain mi_t, which is the estimated effect of migration on the labor force growth.

Naturally, the growth of the labor force cannot be entirely explained by migration, since other factors such as population growth, active labor market policies or early retirement schemes played a important roles (see e.g. Fuchs and Weber, 2005, or DIW Berlin et al., 2002), and these latter factors are not explained in our model. Thus, we define an exogenous residual ($g_{t,x}$), which

[135] Based on our model predictions.

[136] Sources: Bundesagentur für Arbeit (2006) and Statistisches Bundesamt (2005).

[137] Omitting this assumption would mean that East Germany would be completely depopulated when East and West Germany grow at the same rate since the absolute present value differential would grow without recess (because of the time trend).

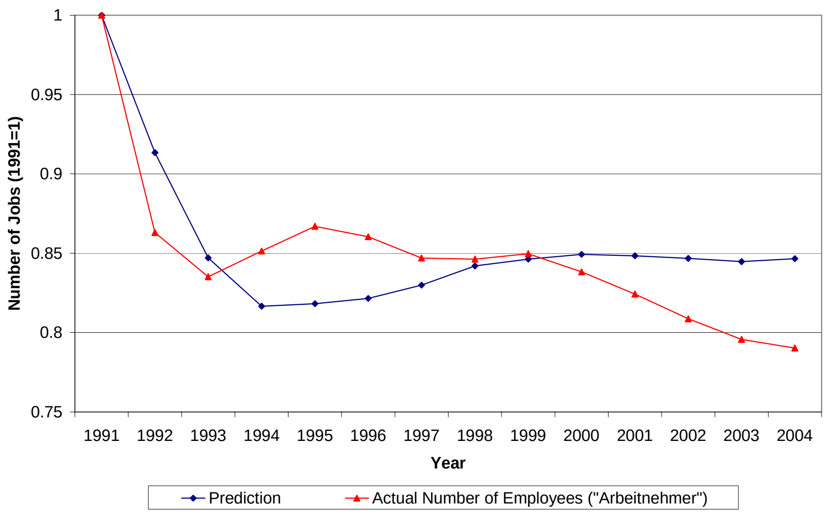


Figure 19: Development of the number of employees (1991=1)

is the difference of the actual labor force growth in the respective year ($g_{t,a}$) minus the effects the calculated effects of migration on the labor force ($mi_{t,m}$), thus reading: $g_{t,x} = g_{t,a} - mi_{t,m}$.

Consequently, the labor force growth rate under different policy exercises is predicted as: $g_{t,a} = mi_{t,m} + g_{t,x}$, where only the migration effects vary, which is calculated based on the estimated coefficients $\tilde{\beta}_1$ and $\tilde{\beta}_2$[138], and the exogenous component stays constant.

The calculated hiring and hiring rates and the labor market growth are then substituted into the employment dynamics curve (159), in order to generate our predicted path of employment rates as well as the path under self-sufficient bargaining.

5.4.3 Results

Fig. (19)[139] shows the time series of the actual employment development and the predicted employment. Note that our model predicts an improvement of employment since the mid-nineties, whereas the actual numbers do not do so. This discrepancy could be captured by our trap model.

Figure (20) shows the prediction of employment rate under different policy exercises and the actual development (excluding job creation programs, which

[138]The estimated values for $\tilde{\beta}_1$ and $\tilde{\beta}_2$ can be found in the Appendix.

[139]Note that employment rates are shown in figure (14). The employment path in figure (19) is derived from the employment rates and the labor force growth rate.

cannot be captured by our model).[140]

Observe that the bargaining by proxy curve tends towards the self-sufficient bargaining prediction, in agreement with our observation that self-sufficient bargaining is becoming increasingly pervasive in East Germany.

In this context, we now consider the effects of two policies:

1. reducing the ratio of firing costs to wages by 5% and

2. reducing the replacement ratio (of unemployment benefits to wages) by 5%.

We examine these policies under self-sufficient bargaining. For this purpose, we linearize equation (225) with respect to all variables determining future profits $E_t\left[\Pi_{t+1}\right]$. See Appendix for technical details.

Fig. (20) tells an interesting story about various ingredients of the "caring hand." It shows that if the firing cost ratio and the replacement ratio would both have been reduced by 5%, the employment path ("SS barg + f and rr reduction" in the figure) would have risen substantially above the employment rates under self-sufficient bargaining alone, which in turn is substantially above the actual employment path.

These two policies are complementary in our model. For example, a reduction in the replacement ratio reduces the wage and thereby reduces the firing rate; this gives more leverage to the employment-promoting influence of a reduced firing cost (via wage reduction), since this reduced firing cost and wage is paid over a longer expected job tenure. Such policy complementarities, along with the migration induced by the policies, account for the magnitude of the employment effects.

Including labor market traps in our calibration would of course imply that, in the absence of sufficiently large positive shocks, employment rates would display little tendency to recover from their post-unification trough. In this context, our analysis implies that East German employment rates would have been higher over the past decade if the initial downturn in employment had been less encumbered by the West German "caring hand."

[140] It is worth noting that differences to figure (19) arise because of the exogenous growth of the East German labor force. The East German labor force (excluding Berlin), defined as employed plus unemployed, grew from 1995 to 1997. Consequently, the predicted increased number of jobs is not visible in the predicted employment rate. The actual employment rates in figure (20) include Berlin, which enables us to exclude job creation programs from the data.

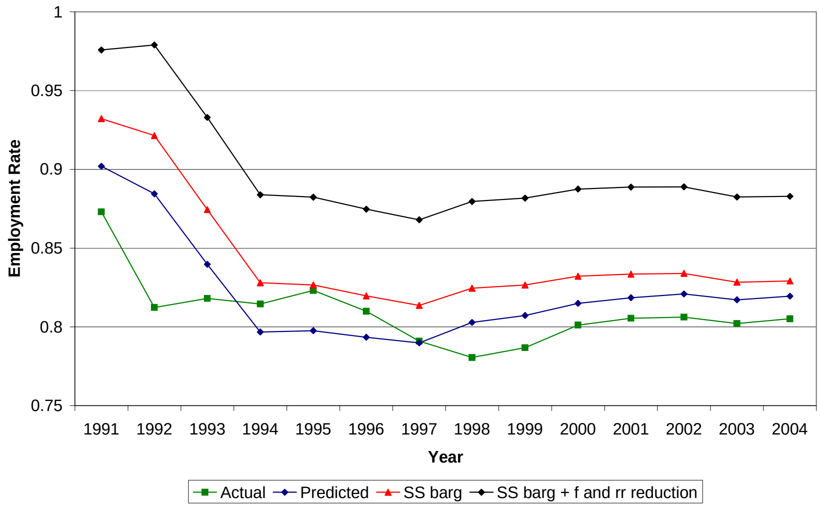


Figure 20: Employment rates under different policies

5.5 Concluding Thoughts

This chapter provides a sober assessment of the East German labor market problem, suggesting that this problem has been exacerbated by various forms of "care" that the East has received from the West: support in bargaining, unemployment benefits, and job security provisions, in particular.

Our analysis also implies that it is pointless to wait for the problem to disappear of its own accord. In the absence of fundamental policy reform, the damage is permanent, not temporary. The reasons are that (i) even once the East Germans gain control over their own wages, the resulting wage negotiations - based on generous unemployment benefits and job security provisions - will still generate wages that are high relative to productivity and (ii) the resulting unemployment can become perpetuated through various labor-market traps. Without a policy reform package that is "deep" (radically improves employment incentives) and "broad" (a range of complementary measures),[141] East Germany is likely to remain dependent on the caring hand that cripples.

[141] See, for example, Coe and Snower (1997).

5.6 Technical Appendix

5.6.1 Further Empirical Evidence

In table (5), we borrow an example from Burda (1994, p. 8) which nicely illustrates what happened in the dawn of transition (from 1990 to 1993), by comparing some numbers for East Germany and Czech Republic:

East Germans enjoyed significant real wage increases due to bargaining by proxy and the introduction of the Deutsch Mark. The latter served as an anchor and prevented prices to increase by the same magnitude as in other Eastern European countries. Nevertheless, there were considerable price increases in the non-tradable sector. The drop in real GDP was similar in East Germany and in Czech Republic. East Germans did not perform worse because they received massive consumption transfers and investments into the infrastructure, which was by the most part paid by the West. Transfers boosted the non-tradable sector, especially the construction industry, where a boom-bust cycle was initiated whose consequences can still be seen today (the construction industry in East Germany is still shrinking).

5.6.2 Theoretical Derivations: Bargaining by Proxy

Since the present value of the worker's surplus is time-invariant, the present value of the firm's surplus is time-invariant as well. Thus the solution of the Nash optimization is time-invariant:

$$\widehat{n}_t = \widehat{n}. \tag{171}$$

Then the present values from equations (162) and (163) can be expressed as

$$\begin{aligned} \Lambda_w &= (\hat{y}_i - \hat{y}_o)\left(\sum_{t=0}^{\infty} \delta^t \hat{n}_t\right) = (\hat{y}_i - \hat{y}_o)\,\widehat{n}\left(\sum_{t=0}^{\infty} \delta^t\right) \\ &= (\hat{y}_i - \hat{y}_o)\,\widehat{n}\frac{1}{1-\delta} \end{aligned} \tag{172}$$

$$\begin{aligned} \Lambda_f &= \sum_{j=0}^{\infty} \delta^t \left(\widehat{o}_a - \widehat{o}_n \hat{n}_{t+j}\right) \\ &= \frac{\widehat{o}_a}{1-\delta} - \frac{\widehat{o}_n \widehat{n}}{1-\delta} \end{aligned} \tag{173}$$

Changes (1990-1993)	GDP	Prices	W[142]	N[143]	U[144]	CAD[145]
East Germany	-22%	+34%	62%	-34%	16%	77%
Czech Republic	-21%	+110%	-18%	-8%	4%	1%

Table 5: Comparison of Czech Republic and East Germany

$$\frac{\partial \Lambda_w}{\partial n} = \frac{\hat{y}_i - \hat{y}_o}{1-\delta} \tag{174}$$

$$\frac{\partial \Lambda_f}{\partial n} = -\frac{\widehat{o}_n}{1-\delta} \tag{175}$$

Inserting these into the Nash equation:

$$\mu \left(\Lambda_w\right)^{-1} \frac{\partial \Lambda_w}{\partial n_0} \left(\Lambda_f\right) + (1-\mu) \frac{\partial \Lambda_f}{\partial n_0} = 0 \tag{176}$$

After some re-formulation we obtain:

$$\widehat{n} = \mu \frac{\widehat{o}_a}{\widehat{o}_n} \tag{177}$$

Thus:

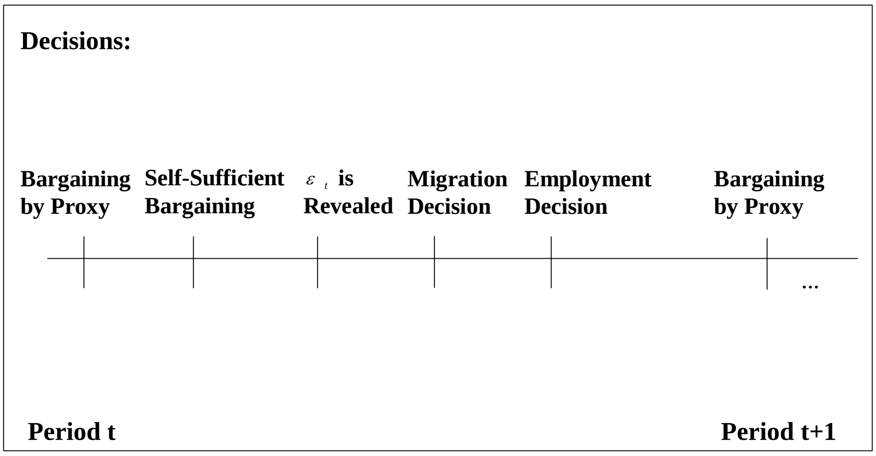
$$\widehat{n} = \mu \frac{\widehat{a} - \widehat{w} - \widehat{h}\widehat{\eta} + \widehat{f}}{\widehat{f}\widehat{\phi} - \widehat{h}\widehat{\eta}} \tag{178}$$

The greater the West German productivity $\hat{a}$ and the greater the workers' bargaining strength μ, the greater is the West German target employment rate and the higher the East German wage will be set. The lower the migration costs co, the higher will be the East German wage corresponding to a given West German target employment rate. In this way our model shows why the East German labor market suffered on account of a purported "strength" of the West German labor market - high productivity - and purported "advantages" of the East Germans - the ability to migrate to the wealthy West and increased bargaining power bestowed by their Western counterparts.

5.6.3 Detailed Description of the Calibration

Hiring and Firing under Constant Growth Rates:

Sequencing of Decisions: There is an operating cost ξ_t that is a random variable, with a cumulative distribution $\Gamma\left(\xi_t\right)$, which is normalized to zero and iid across workers and time. See figure (28) for an illustration of the sequencing.



Time Axis

Figure 21: Sequencing of decisions

Under *bargaining by proxy*, West German firms and workers bargain for the East German wage level. In sectors where *self-sufficient bargaining* prevails, East German firms and insiders bargain for their wage, as described in equation (161). We assume that insiders seek to maximize the utility of the representative insider (the median voter).

After the operating costs are revealed East Germans decide if they want to migrate, based on their present value of income. Finally, the employment decision is taken. If a firm hires a worker, it has to pay the operating cost ξ_t. The current profit generated by the worker is $\Pi_t = a_t - w_t - \xi_t$.

Workers who are hired or not fired remain employed until the end of the period (the opposite is true for workers who are fired or not hired). At the beginning of the next period $(t+1)$, the same process starts again.

Firing Rate: When the productivity, wages (labor costs) and firing costs trend all along the same constant time path and when this constant time path is equal to the trend of the operating costs, then the hiring and firing rates are constant (see theoretical part where we assumed a zero growth rate for simplicity). We assume that there are constant returns to labor.

Let the firing rate be ϕ. In the initial period, the insider generates a profit of $a - w - \xi$; if he is fired at the beginning of the next period (with probability ϕ), then he generates a cost of ζf (under the assumption that wages, productivity, and the firing costs grow at a rate of $\zeta - 1$ per year, with $\zeta > 1$[146]); if he is retained at the beginning of the next period (with probability $(1-\phi)$), then he generates an expected profit of $\zeta(a-w)$. At the beginning of the third period, the probability of being retained is $(1-\phi)^2$, and the probability of being retained at the beginning of the second period but fired in the third is $(1-\phi)\phi$; and so on. Thus the present value of the profit generated by an insider is

$$\begin{aligned}
\Pi_i &= (a-w) - \xi + \left(\delta\zeta(1-\phi)(a-w) + (\zeta\delta)^2(1-\phi)^2(a-w) + ...\right) \\
&\quad -\zeta\delta\left(\phi f + (1-\phi)\phi\zeta\delta f + (1-\phi)^2\phi\zeta^2\delta^2 f + ...\right) \\
&= (a-w) - \xi + \sum_{t=1}^{\infty}(\zeta\delta)^t(1-\phi)^t(a-w) - \zeta\delta\phi f\sum_{t=0}^{\infty}(\zeta\delta)^t(1-\phi)^t \\
&= -\xi + \frac{a-w}{1-\zeta\delta(1-\phi)} - \frac{\zeta\delta\phi f}{1-\zeta\delta(1-\phi)} \qquad (179)
\end{aligned}$$

$$\Pi_i = -\xi + \frac{(a-w) - \zeta\delta\phi f}{1-\zeta\delta(1-\phi)} \qquad (180)$$

where δ is the discount factor ($\delta < 1$).

A worker is fired when his present value of profit is less than $-f$ (the firing cost).

$$\begin{aligned}
-\xi + \frac{(a-w) - \zeta\delta\phi f}{1-\zeta\delta(1-\phi)} &< -f && (181a) \\
\xi &> \frac{(a-w) - \zeta\delta\phi f}{1-\zeta\delta(1-\phi)} + f && (181b) \\
\xi &> \frac{(a-w)}{1-\delta\zeta(1-\phi)} - \frac{\zeta\delta\phi f}{1-\delta\zeta(1-\phi)} + f && (181c) \\
\xi &> \frac{(a-w) + (1-\zeta\delta) f}{1-\zeta\delta(1-\phi)} && (181d)
\end{aligned}$$

Thus, the probability of being fired is:

$$\phi = 1 - \Gamma\left(\frac{(a-w) + (1-\zeta\delta) f}{1-\zeta\delta(1-\phi)}\right) \qquad (182)$$

[146] We set the infinite growth rate to 2%. Thus $\alpha = 1.02$.

Hiring Rate: A worker is hired at the beginning of the period if the expected profit is bigger than the hiring costs:

$$\Pi > h \tag{183a}$$

$$-\xi + \frac{(a-w) - \zeta\delta\phi f}{1-\zeta\delta(1-\phi)} > h \tag{183b}$$

$$\xi < \frac{(a-w) - \zeta\delta\phi f}{1-\zeta\delta(1-\phi)} - h \tag{183c}$$

Thus:

$$\eta = \Gamma\left(\frac{(a-w) - \zeta\delta\phi f}{1-\zeta\delta(1-\phi)} - h\right) \tag{184}$$

Time Varying Parameters:

Firing Rate: To control for the time trend in the data, we first of all deflated all productivity (defined as gross value added per employee) and labor cost (defined as gross wages plus additional social security payments of the employers) numbers (by dividing by the 1991 German GDP deflator). Furthermore, we assume that the distribution of the operating costs shifts along a 2% time trend, starting at $\zeta^1\xi_t$ in 1991.

We assume for simplicity that companies expect wages, productivity and firing costs to trend along a constant 2% growth path from period 2004 onwards ($\zeta > 1$) for self sufficient bargaining, starting at their estimated 2004 value (see below for the calculation). The same is true for our prediction, based on actual values, from 2014 onwards when this path has converged to the self-sufficient bargaining path. We assume that the actual real wage in 2004 adjusts linearly to the self-sufficient real wage in 2014.

For the 1991 to 2004 values we assume perfect foresight. We use the 2004 value for self-sufficient bargaining as an anchor and calculate all other firing rates in the model with a first order Taylor series expansion with respect to this point. Furthermore the 2004 values for self-sufficient bargaining are set in such a way that the firing rate for predictions, based on the actual values, is 12.5% in 2004 and the hiring rate is 57% in 2004.

The expected present value of profits in 2005 for self-sufficient bargaining is equal to:

$$\Pi_{2005} = -\xi_{2005} + \frac{\zeta\left[(a-w)-\zeta\delta\phi f\right]}{1-\zeta\delta\left(1-\phi\right)} \tag{185}$$

Thus, firms expect the following profits for a worker in period $t-1$ (if he is retained):

$$E_{2004}\left(\Pi_{2005}\right) = \left[\zeta\frac{\left[(a-w)-\zeta\delta\phi f\right]}{1-\zeta\delta\left(1-\phi\right)}\right] \tag{186}$$

where ϕ is the infinite firing rate.

The profit in 2004 writes as follows:

$$\Pi_{2004} = -\zeta^{14}\xi + a_{2004} - w_{2004} - \phi\zeta\delta f + \delta\left(1-\phi\right)\left[\zeta\frac{\left[(a-w)-\zeta\delta\phi f\right]}{1-\zeta\delta\left(1-\phi\right)}\right]. \tag{187}$$

The firm has to pay the operating costs and earns the productivity minus the wage. If it does not retain the worker at the beginning of period $t+1$, it has to pay the firing cost. Otherwise it earns the expected future present value of this worker.

Letters without time subscripts denote the long-run values. Letters with time subscripts denote the numbers in the respective period.

Firms fire a workers at the beginning of 2004 if $\Pi_{2004} < -f_{2004}$.

$$\begin{aligned} \zeta^{14}\xi \;&>\; a_{2004} - w_{2004} + f_{2004} \\ &\quad -\delta\zeta\phi f + \delta\left(1-\phi\right)\left[\zeta\frac{\left[(a-w)-\zeta\delta\phi f\right]}{1-\zeta\delta\left(1-\phi\right)}\right] \end{aligned} \tag{188}$$

Thus:

$$\phi_{2004} = 1 - \Gamma\left(\begin{array}{c} \frac{1}{\zeta^{14}}\left(a_{2004} - w_{2004}\right) + \frac{1}{\zeta^{14}} f_{2004} \\ -\frac{1}{\zeta^{14}}\delta\zeta\phi f + \delta\frac{1}{\zeta^{14}}\left(1-\phi\right)\left[\zeta\frac{\left[(a-w)-\zeta\delta\phi f\right]}{1-\zeta(1-\phi)}\right] \end{array}\right) \tag{189}$$

In period 2003 the expected future present value in case of retention is defined as:

$$E_{2003}\left(\Pi_{2004}\right) = \left(\begin{array}{c} a_{2004} - w_{2004} - \delta\phi\zeta f \\ +\delta\left(1-\phi\right)\left[\zeta\frac{\left[(a-w)-\zeta\delta\phi f\right]}{1-\zeta(1-\phi)}\right] \end{array}\right), \tag{190}$$

and so on.

Or generally:

$$\phi_t = 1 - \Gamma \left(\begin{array}{c} \frac{1}{\zeta^t}\left(a_t - w_t\right) + \frac{1}{\zeta^t} f_t \\ -\frac{1}{\zeta^t}\delta\phi_{t+1} f_{t+1} + \frac{1}{\zeta^t}\delta\left(1 - \phi_{t+1}\right) E_t\left(\Pi_{t+1}\right) \end{array} \right). \tag{191}$$

We linearize the firing rate with respect to the anchor (which is the year 2004 under self-sufficient bargaining).

$$\begin{aligned} \phi_t &= \phi_0 - \frac{1}{\zeta^t}\Gamma'_0\left[\left(a_t - w_t\right) - \left(a_{t,0} - w_{t,0}\right)\right] \\ &\quad -\frac{1}{\zeta^t}\Gamma'_0\left[\left(f_t - f_{t,0}\right)\right] + \frac{1}{\zeta^t}\delta\phi_0\Gamma'_0\left(f_{t+1} - f_{t+1,0}\right) \\ &\quad -\delta\frac{1}{\zeta^t}\left(1 - \phi_0\right)\Gamma'_0\left(E_t\left[\Pi_{t+1}\right] - E_{t,0}\left[\Pi_{t+1}\right]\right) \end{aligned} \tag{192}$$

Remark that we detrend the anchor variables. In t, e.g. $a_{t-n,0} = \left(\frac{1}{\zeta}\right)^n a_{t,0}$. The reason is that there would be no change of the firing rate if all variables would just grow along their 2% trend per period.

Hiring Rate: The firm hires in 2004 if $\Pi_{2004} > h_{2004}$.

$$-\zeta^{14}\xi_{2004} + a_{2004} - w_{2004} - \phi\delta\zeta f_{2005} + \delta\left(1 - \phi\right)\left[\zeta\frac{\left[\left(a - w\right) - \zeta\delta\phi f\right]}{1 - \zeta\delta\left(1 - \phi\right)}\right] - h_{2004} > 0, \tag{193}$$

The cumulative function for the hiring rate in period t-1 looks as follows:

$$\eta_{2004} = \Gamma \left(\begin{array}{c} \frac{1}{\zeta^{14}}\left(a_{2004} - w_{2004}\right) - \frac{1}{\zeta^{14}} h_{2004} - \\ \frac{1}{\zeta^{14}}\phi\zeta\delta f + \left(1 - \phi\right)\delta\frac{1}{\zeta^{14}} E_{2004}\left(\Pi_{2005}\right) \end{array} \right), \tag{194}$$

or generally speaking:

$$\eta_t = \Gamma\left(\frac{1}{\zeta^t}\left(a_t - w_t\right) - \frac{1}{\zeta^t} h_t - \frac{1}{\zeta^t}\phi_{t+1}\delta f_{t+1} + \left(1 - \phi_{t+1}\right)\delta\frac{1}{\zeta^t} E_t\left(\Pi_{t+1}\right)\right). \tag{195}$$

After linearizing, we obtain:

$$
\begin{aligned}
\eta_t &= \eta_0 + \frac{1}{\zeta^t}\Gamma'_0 \left[(a_t - w_t) - (a_{t,0} - w_{t,0})\right] \qquad (196)\\
&- \frac{1}{\zeta^t}\Gamma'_0 \left(h_t - h_{t,0}\right) - \frac{1}{\zeta^t}\delta\phi_0\Gamma'_0 \left(f_{t+1} - f_{t+1,0}\right)\\
&+ \left(1 - \phi_0\right) \frac{1}{\zeta^t}\delta\Gamma'_0 \left(E_t\left[\Pi_{t+1}\right] - E_{t,0}\left[\Pi_{t+1}\right]\right)
\end{aligned}
$$

Calculation of Alternative Wage Paths: We use the model to predict what would have happened under alternative scenarios. Therefore, we calculate the labor costs under (i) self-sufficient bargaining and (ii) 5% lower firing costs and replacement rates in addition. To do so, we assume that the replacement rate is 60%, the firing costs are 60% and the hiring costs are 10% of labor costs.

Therefore, we calculate the bargaining parameter $\hat{\mu}_t$ for West Germany

$$\hat{w}_t = (1 - \hat{\mu}_t)\,\hat{b}_t + \hat{\mu}_t\left(\hat{a}_t + \widehat{f_t}\right) \qquad (197)$$

$$\hat{\mu}_t = \frac{\hat{w}_t\,(1 - rr)}{\hat{a}_t + \hat{f}_t - rr\hat{w}_t} \qquad (198)$$

Assuming that East Germans would have the same bargaining parameter as their West German counterparts ($\mu_t = \hat{\mu}_t$), we estimate the East German wage under self-sufficient bargaining:

$$
\begin{aligned}
w_t &= (1 - \hat{\mu}_t)\,rr * w_t + \hat{\mu}\,(a_t + f_t) \qquad (199)\\
w_t &= \frac{\hat{\mu}_t a_t}{1 - (1 - \hat{\mu}_t)\,rr - \hat{\mu}_t d} \qquad (200)
\end{aligned}
$$

where d is the dependence of the firing costs on the wage level, which was set to 60%.

Using the above formula, we calculate the presumable labor costs under self-sufficient bargaining from 1991 to 2004. We do the same for a 5% lower replacement rate and 5% lower firing costs: $f_{t,new} = 0.95 f_{t,old}$ and $rr_{t,new} = 0,95 rr_{t,old}$. Next, we use these wage numbers to predict the alternative employment paths.

Policy Exercise with Lower Firing Costs and Replacement Ratio: For the policy exercise with lower firing costs and a lower replacement ratio, we need to know the infinite firing rate to be able to calculate the expected present value of a worker in 2004.

In 2005 a worker is fired if:

$$\zeta^{15}\xi_t > \frac{\zeta(a-w)}{1-\delta\zeta(1-\phi)} + \frac{\zeta(1-\zeta\delta) f}{1-\delta\zeta(1-\phi)} \tag{201}$$

We know that ξ and all other variables are trending at a rate ζ until infinity. Thus long-run firing rate is equal to

$$\phi = 1 - \Gamma\left(\frac{1}{\zeta^{14}}\frac{(a-w)+(1-\zeta\delta) f}{1-\delta\zeta(1-\phi)}\right) \tag{202}$$

We linearize it with respect to all variables to determine its value in the new equilibrium:

$$\begin{aligned}
\phi_{new} &= \phi_0 - \frac{1}{\zeta^{14}}\Gamma_0'\left[\frac{1}{1-\zeta\delta(1-\phi)}\right]_0 [(a_{new}-w_{new})-(a_0-w_0)] \\
&\quad -\frac{1}{\zeta^{14}}\Gamma_0'\left[\frac{1-\zeta\delta}{1-\delta\zeta(1-\phi)}\right]_0 (f_{new}-f_0) \\
&\quad -\frac{1}{\zeta^{14}}\Gamma_0'\left[\frac{-\delta\zeta[(a-w)+(1-\zeta\delta) f]}{(1-\delta\zeta(1-\phi))^2}\right]_0 (\phi_{new}-\phi_0)
\end{aligned} \tag{203}$$

where variables denoted with $_{new}$ are the infinite values under the alternative scenario.

Thus:

$$\begin{aligned}
\phi_{new} &= \phi_0 - \frac{1}{1-\frac{1}{\zeta^{14}}\Gamma'\left[\frac{\delta\zeta[(a-w)+(1-\delta\zeta)f]}{(1-\delta\zeta(1-\phi))^2}\right]_0} \\
&\quad \left[\begin{array}{c} \frac{1}{\zeta^{14}}\Gamma'\left[\frac{1}{1-\delta\zeta(1-\phi)}\right]_0 [(a_{new}-w_{new})-(a_0-w_0)] \\ +\frac{1}{\zeta^{14}}\Gamma'\left[\frac{1-\delta\zeta}{1-\delta\zeta(1-\phi)}\right]_0 (f_{new}-f_0) \end{array}\right]
\end{aligned} \tag{204}$$

The same linearization is performed for the infinite hiring rate, which will be needed later on for the calculation of the expected future wage income stream of a worker.

$$\eta = \Gamma\left(\frac{1}{\zeta^{14}}\frac{(a-w)-\zeta\delta\phi f}{1-\zeta\delta(1-\phi)} - \frac{1}{\zeta^{14}}h\right) \tag{205}$$

When linearizing, we obtain:

$$
\begin{aligned}
\eta_0 &= \eta_0 + \Gamma_0' \left[\frac{1}{\zeta^{14}} \frac{1}{1 - \zeta\delta(1-\phi)} \right]_0 \left[(a_{new} - w_{new}) - (a_0 - w_0) \right] \\
&\quad - \Gamma_0' \left[\frac{1}{\zeta^{14}} \frac{\delta\zeta\phi}{1 - \zeta\delta(1-\phi)} \right]_0 (f_{new} - f_0) - \Gamma_0' \frac{1}{\zeta^{14}}_0 (h_{new} - h_{old}) \\
&\quad + \Gamma_0' \left[\frac{1}{\zeta^{14}} \frac{-\zeta\delta f (1 - \zeta\delta(1-\phi)) - \zeta\delta \left[(a-w) - \delta\zeta\phi f \right]}{(1 - \zeta\delta(1-\phi))^2} \right]_0 (\phi_{new} - \phi_0)
\end{aligned} \tag{206}
$$

Migration:

Infinite Problem: When all variables are trending along the 2% path (from 2004 onwards for all policy exercises, from 2014 onwards for the prediction), the present value of the future wage income does so too. An insider can either be fired ϕ, or retained $1 - \phi$. The outsider is either hired (η), or stays unemployed ($1 - \eta$). Thus the present value of an insider is:

$$
\bar{V}_i = w + \delta \left((1-\phi) \zeta \bar{V}_i + \phi \zeta \bar{V}_o \right). \tag{207}
$$

The present value of an outsider is

$$
\bar{V}_o = b + \delta \left(\eta \zeta \bar{V}_i + (1-\eta) \zeta \bar{V}_o \right). \tag{208}
$$

Thus:

$$
\bar{V}_o = \frac{b + \delta\eta\zeta\bar{V}_i}{(1 - \delta(1-\eta)\zeta)} \tag{209}
$$

$$
\bar{V}_i = \left(w + \delta\phi\zeta \frac{b}{(1 - \delta(1-\eta)\zeta)} \right) / \left(1 - \delta(1-\phi)\zeta - \frac{\delta^2\zeta^2\phi\eta}{(1 - \delta(1-\eta)\zeta)} \right) \tag{210}
$$

Finite Time Horizon: From 1991 to 2004 (and to 2014 for the first prediction) the problem is solved recursively.[147] The present value of an insider in 1991 is

$$
V_{i,t} = w_t + \delta \left(\left(1 - \phi_{t+1}\right) V_{i,t+1} + \phi_{t+1} V_{o,t+1} \right), \tag{211}
$$

[147] We choose this functional form of the insiders' and outsiders' present value for analytical simplicity, but without loss of generality. In combination with (160) it means that East-West migrants are unemployed for one period. Dropping this assumption and changing the sequencing does not affect the results qualitatively.

while it is

$$V_{o,t} = b_t + \delta \left(\eta_{t+1} V_{i,t+1} + \left(1 - \eta_{t+1}\right) V_{o,t+1} \right) \tag{212}$$

for an outsider.

Estimating Migration and Exogenous Labor Force Growth: The labor force (employed plus unemployed) in East Germany is about 50% of the population.[148] To generate the effect of migration on the workforce ($mi_t = MI_{t-1}/L_{t-1}$) we multiply the actual net migration by 0.5 and divide it by the labor force, assuming that migration in period t affects the labor force growth from t to $t+1$.

The available migration numbers include East Berlin until 2001 and entire Berlin from 2001 onwards (see Statistisches Bundesamt, 2005, p. 52). Since our labor force, productivity, and labor cost numbers do not include Berlin, we corrected the number of migrants by the factor 0.9 before 2001 and by the factor 0.8 after 2002.[149] To provide an example: 359,126 net migrants in 1990 were multiplied by 0.5 and the correction factor 0.9. The corresponding number was then divided by the labor force in East Germany in 1990 (about 8.6 million). Thus migration reduced the labor force by -1.8% (mi_t) from 1990 to 1991.[150]

The growth of the labor force cannot be entirely explained by migration, since other factors such as population growth, active labor market policies or early retirement schemes played a very important role (see e.g. Fuchs and Weber, 2005, or DIW Berlin et al., 2002), which cannot be captured by our model. Thus, we define an exogenous residual $g_{t,x} = g_{t,o} - mi_{t,m}$.

For the calibration we have to modify equation (160) slightly. To ensure stationarity we assume that the migration costs of the marginal migrant $co\left(mi_{jt}\right)$, $j = i, o$ grow at the same rate as the operating costs of the firm and all other variables during the steady state. Thus migration is $mi_{j,t} = co^{-1}\left(\frac{K_j}{\zeta^t}\right)$ and we obtain.

$$mi_t = g_t - 1 = co^{-1}\left(\frac{\widehat{V}_{o,t} - V_{i,t}}{\zeta^t}\right) + co^{-1}\left(\frac{\widehat{V}_{o,t} - V_{o,t}}{\zeta^t}\right) \tag{213}$$

[148] Source: "GENESIS-Online - Das statistische Informationssystem," Statistisches Bundesamt (2005).

[149] In proportion to the respective population shares.

[150] For 1990 we do not have official numbers on the size of the labor force from the Bundesagentur für Arbeit (since unificiation took place in October). Thus, we calculate the growth rate for 1990 and 1991 from DIW (1993, p. 256) and DIW (1994, p. 731).

	Est. Coefficients	SE[154]	t-Statistics	p-Value	R Square
beta 1	0.04	0.01	2.63	0.02	0.42
beta 2	-8.7*10^-8	0.00	-2.96	0.01	

Table 6: Estimation of migration coefficients. dependent variable: mi(t).

In a next step, we estimate $mi_{t,m} = \beta_1 + \beta_2 \left[\left(2\widehat{V}_{o,t} - V_{i,t} - V_{o,t} \right) / \zeta^t \right]$[151] to determine an as good as possible fit between our prediction and the actual values.[152] We use the estimated coefficients $\tilde{\beta}_1$ and $\tilde{\beta}_2$ to obtain $\tilde{m}i_{t,m}$ for different policy exercises, which is the estimated effect of migration on the labor force growth. See figure (6) for the estimated coefficients.[153]

Consequently, the labor force growth rate under different policy exercises is calculated as $g_{t,o} = \tilde{m}i_{t,m} + g_{t,x}$, where only the estimated migration effects varies and the exogenous component stays constant.

Employment Dynamics Curve: The calculated hiring and hiring rates and the labor market growth are then plugged into the employment dynamics curve:

$$n_t = \frac{1}{g_{t,o}} \left(\eta_t + \left(1 - \eta_t - \phi_t \right) n_{t-1} \right). \tag{214}$$

[151]We do not model West Germany explicitly. To calculate the expected present value of a worker who migrates there, we assume constant firing (8%) and hiring rates (72%), see Wilke (2004). Furthermore, we assume that all variables are trending along a 1.5% trend in West Germany until East Germany has converged to the West German level. Afterwards West Germany's (without the burden of transfer payments, which are currently running at 4% of GDP) variables continue to grow at 2% as well. For the years from 1991 to 2004 we use the actual labor cost numbers from Statistische Ämter des Bundes und der Länder (2005).

[152]Therefore, we use ordinary least squares which minimize the squared deviation of the actual from the predicted values.

[153]In this estimation net East-West migration is marked with a negative sign.

6 Escaping the Unemployment Trap

6.1 Introduction

The persistence of large European regional unemployment differentials - particularly within the large European economies, France, Germany, Italy and Spain - remains a challenge to economists, despite a prodigious literature on the subject (e.g. Decressin and Fatás, 1995, Elhorst, 2005, Faini et al., 1997, Gray, 2004, Sinn and Westermann, 2001, Taylor and Bradley, 1997). The mystery is not how these unemployment differentials arose, for usually regions of relatively high unemployment are generally ones in which labor costs have been relatively high in relation to productivity. Rather, the mystery is why unemployment differentials far outlive their original causes. Specifically, once the unemployment differentials have persisted for a long time, then they do not go away, even after labor costs fall relatively to productivity. Why?

East Germany is a good case example. After German reunification in 1991, East German real wages rose dramatically relative to productivity and unemployment jumped upwards in response. With the social and monetary union in October 1990, East German labor costs jumped from 7% (using the informal exchange rate) to about one half of the West German level (see e.g. Franz and Steiner, 2000, Sinn, 2002). Since then, however, labor costs have fallen steadily in relation to productivity, but the employment rate has remained stubbornly low, hovering near 20 percent for the past decade (see figure (18)[155]). Traditional labor market analysis has trouble accounting for this experience.

This chapter[156] suggests a simple explanation[157]: Once people remain unemployed for a long time, they tend to fall into a "trap" representing a contraction of their employment opportunities. In Chapter 5, we describe several such traps, but do not model them. Consider a few examples.

Immediately after German reunification, East German wage bargaining was conducted primarily by *West German* unions and employers, and these had strong incentives to push East German wages up, in order to reduce migration of East German workers to West Germany and of West German firms to the East. Given the low short-run elasticity of labor demand, this "bargaining by proxy" was not only in the interests of West German unions, but also West

[155] Sources: Bundesagentur für Arbeit (2006a, b) and Statistische Ämter des Bundes und der Ländern (2006), own calculations.

[156] For a different version of this chapter see "Escaping the Unemployment Trap - The Case of East Germany -" with Dennis Snower, Kiel Working Paper, No. 1309, January 2007.

[157] For an alternative explanation see Uhlig (2006).

German firms who feared the entry of new firms sparked by the new migration flows. The upward wage pressure was reinforced through generous unemployment benefits and associated welfare entitlements. The resulting East German wage hike led to a sharp fall in East German employment, and this effect was prolonged through the introduction of generous job security provisions and costly hiring regulations, which raised the persistence of employment (i.e. made current employment depend more heavily on past employment). The persistently low employment was mirrored in long-term unemployment.[158]

This is where possibility of traps arises. The long-term unemployed are prone to attrition of skills and work habits and they are of course unable to get on-the-job training. As their productivity falls, they find more difficult to find jobs, even if labor costs fall relative to the average productivity of the employed workforce.

Naturally, if these "efficiency labor costs," i.e. labor costs deflated by average productivity, fell sufficiently to more than compensate for the drop in the productivity of the long-term unemployed, then their employment opportunities would improve; but the data appear to suggest that these costs did not fall enough.

Furthermore, the massive East German investment subsidies that were granted in the aftermath of reunification - often paid to prevent uncompetitive firms to lay off their employees - resulted in the creation of capital that was relatively unproductive and prone to underutilization (see, for example, Sinn, 1995). The labor cooperating with this capital became similarly unproductive and underutilized, even if efficiency labor costs subsequently fall.

What these traps have in common is that they are both associated with low productivity[159]: the long-term unemployed are prone to become less productive and this traps them in unemployment. The drop in productivity may arise either because workers lose skills or because they lose access to "good jobs" (i.e. highly productive, well-paying ones).

This chapter models such a trap, and examines its implications for labor market activity and employment policy. We build an analytical model of the low-productivity trap and calibrate it for the East German labor market. In this context, we inquire which policies are effective in creating employment.

[158]The share of long-term unemployed (with a duration of more than one year) has increased from one quarter in 1992 to roughly one half today (Sachverständigenrat, 2004).

[159]See Fuchs-Schündeln and Izem (2007) and Ragnitz (2007) for a thorough analysis of the low labor productivity in East Germany. See Burda (2006) for a neo-classical model of economic integration with adjustment costs, which explains the "capital deepening" and the "labor thinning" in the East.

The trap highlights a major, often ignored, cost of long-term unemployment. A specific rise in efficiency labor costs sends employees into short-term unemployment; but should this state persist and thus turn into long-term unemployment, then an equal and opposite fall in efficiency labor costs may be insufficient to bring these workers back into employment.

Our notion of a labor market "trap" is related to the literature on segmented labor markets, for example, models that divide the labor market into a high-wage "primary sector" and a "secondary sector" that is market clearing.[160]

This chapter contributes to this literature by explaining sources of mobility between the two sectors and examining the implications for employment and unemployment dynamics. As noted, our model describes a labor market where workers in the primary sector who become unemployed risk losing their skills or their access to high-productivity jobs (for instance, because they become stigmatized and demotivated through their unemployment spell), and thereby they risk sinking into the "trapped" sector. The longer they are unemployed, the greater this risk becomes. On the other hand, workers who are employed in the trapped sector may gain skills or access to high-productivity jobs (e.g. by using their jobs to gain information and contact to other employment opportunities), and thereby they may rise into the primary sector. The longer they remain employed, the greater is the likelihood of rising. In short, unemployment is the road to bad jobs and long-term unemployment, whereas employment is the road to good jobs and shorter unemployment spells.

As shown below, these dynamic relations have important implications not only for the persistence of employment and unemployment, but also for the effectiveness of labor market policies. Specifically, we show that

- the existence of low-productivity traps implies that reductions in wages in the trapped sector (induced, say, by cuts in unemployment benefits or firing costs), on their own, are relatively ineffective in raising the corresponding employment rate (both in relation to the primary sector and an economy without low-productivity traps).

- hiring subsidies for the trapped unemployed have a relatively strong positive influence on employment, i.e. for a given subsidy size (both absolute

[160]See, for example, Bulow and Summers (1986), McDonald and Solow (1985), Weitzman (1989), Dickens and Lang (1988) for the early foundations of this literature and Kleven and Sorensen (2004) and Lommerud et al. (2004) for more recent contributions. For the empirical literature see, for example, Dickens and Lang (1985), Saint-Paul (1996) for a survey and Ghilarducci and Lee (2005) for a recent contribution.

and relative to the wage) they are more cost-effective[161] than hiring subsidies for primary unemployed. There are two driving forces: The presence of traps reduces the deadweight effects of hiring subsidies and hiring subsidies enable more trapped workers to move to the primary sector via on the job training.

- training subsidies and programs that raise the productivity of workers in the trapped sector, thereby improving their chances of entering the primary sector, may also have a relatively strong employment long-run effect, but this effect takes a long time to manifest itself.

The chapter is organized as follows. Section 2 presents our model. In Section 3 this model is calibrated for the East German labor market. Section 4 considers the policy implications. Finally, Section 5 concludes.

6.2 The Model

Our labor market has a "primary" sector and a "trapped" sector. The average productivity per worker in the trapped sector is assumed to be lower in the trapped (a_{tr}) than in the primary sector (a_{pr}). Moreover, firms face a random cost ξ_t, iid across workers and time, with a constant cumulative distribution $\Gamma(\xi_t)$. This cost may be interpreted as an operating cost or as a negative productivity shock.

Decisions in the labor market are made in the following sequence: First, workers move between sectors. Specifically, each unemployed worker in the primary sector has an exogenously given probability ν of losing productivity and thereby entering the trapped sector (due either to skill attrition or loss of access to good jobs); and each employed worker in the trapped sector has an exogenously given probability ϖ of gaining productivity and thereby ascending to the primary sector.[162] Second, the wage is determined through bargaining. Third, the value of the random cost ξ_t is revealed. Finally, firms make their hiring and firing decisions.

Let the hiring rates of workers in the primary and trapped sectors be η_{pr} and η_{tr}, respectively, and let their firing rates from these sectors be ϕ_{pr} and ϕ_{tr}, respectively. (These hiring and firing rates will be derived choice-theoretically

[161] We call a policy more "cost effective" than another policy when it generates more employment, for a given net government expenditure outlay.

[162] Thus the cumulative probability of that an unemployed primary worker falls into the low-productivity trap rises with the duration of unemployment, and the cumulative probability of an employed trapped worker to escape from the trap rises with employment duration.

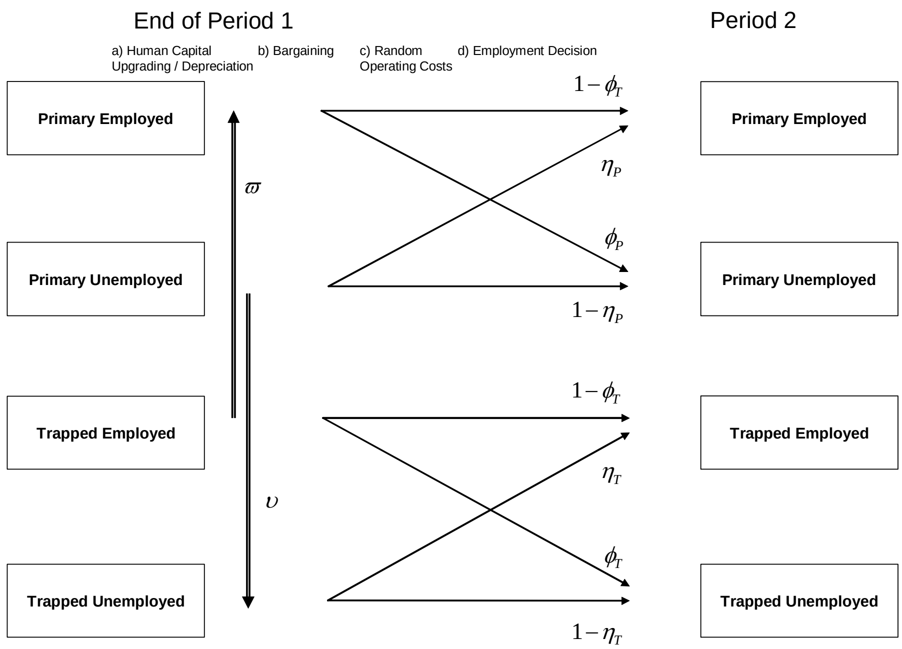


Figure 22: Transition probabilities

below.) The transitions between the various economic states are pictured in figure (22). Each employed primary and trapped worker remains employed with probability $\left(1-\phi_{pr}\right)$ and $(1-\phi_{tr})$, respectively; she becomes unemployed with probability ϕ_{pr} and ϕ_{tr}, respectively. Each unemployed primary and trapped worker remains unemployed with probability $\left(1-\eta_{pr}\right)$ and $(1-\eta_{tr})$, respectively; she becomes employed with probability η_{pr} and η_{tr}, respectively.

6.2.1 Wage Determination

We assume that the wage is the outcome of a Nash bargain between the median insider and her firm in the respective sector.[163] The median insider faces no

[163] The critical reader may object that insider power has been seriously eroded in East Germany due to the fall in union membership since reunification. The first response to this objection is that we should not confuse our insider bargaining with union bargaining, since our Nash bargaining problem could be interpreted as the individual median insider bargaining with her firm. Second, much of the erosion of East German insider power since reunification has resulted from the replacement of bargaining by proxy (in which West German unions and firms had dominant influence on negotiations about East German wages) by self-sufficient bargaining (in which East German workers and firms have taken control of East German wage determination). In our model, we assume that East German wage determination is entirely self-sufficient in this sense. And finally, although union membership has dropped in East Germany, union wage agreements still have very broad coverage. For example, in 2003 firms that were covered by a firm level or sectoral wage agreement employed 54 percent of all workers in East Germany. A large share of the other firms followed existing

risk of dismissal at the negotiated wage.[164]

There are constant returns to labor.[165] Under bargaining agreement, the insider receives the wage $w_{tr,t}$ and the firm receives the expected profit $(a_{tr} - w_{tr,t})$ in each period t. The expected present value of returns to a trapped insider under bargaining agreement $\left(V_{tr,t}^{I}\right)$ is

$$V_{tr,t}^{I} = w_{tr,t} + \delta \left(\begin{array}{c} (1-\varpi)\left(1-\phi_{tr,t+1}\right)V_{tr,t+1}^{I} + (1-\varpi)\,\phi_{tr,t+1}\,(1-\varpi)\,V_{tr,t+1}^{U} \\ +\varpi\left(1-\phi_{pr,t+1}\right)V_{pr,t+1}^{I} + \varpi\phi_{pr,t+1}V_{pr,t+1}^{U} \end{array} \right) \tag{215}$$

where δ is the discount factor and $V_{tr,t+1}^{U}$ ($V_{pr,t+1}^{U}$) is the expected present value of returns of an unemployed trapped (primary) worker and $V_{tr,t+1}^{I}$ ($V_{pr,t+1}^{I}$) is the expected present value of returns of an employed trapped (primary) worker, respectively. Note that with probability ϖ a trapped worker is upgraded to the primary sector and thus has a higher future present value. The expected present value of returns to the firm under bargaining agreement is

$$\widetilde{\Pi}_{tr,t}' = (a_{tr} - w_{tr,t}) + \delta \left(\begin{array}{c} (1-\varpi)\left(1-\phi_{tr,t+1}\right)\widetilde{\Pi}_{tr,t+1}^{I} - (1-\varpi)\,\phi_{tr,t+1}f_{tr,t+1} \\ +\varpi\left(1-\phi_{pr,t+1}\right)\widetilde{\Pi}_{pr,t+1}^{I} - \varpi\phi_{pr,t+1}f_{pr,t+1} \end{array} \right) \tag{216}$$

where $\widetilde{\Pi}_{tr,t+1}^{I}$ ($\widetilde{\Pi}_{pr,t+1}^{I}$) is the future profit in the trapped (primary) sector, weighted with the probability that the worker stays in the respective sector.

Under disagreement, the insider's fallback income is $b_{tr,t}$, assumed equal to the unemployment benefit. The firm's fallback profit is $-f_{tr,t}$, which is the firing cost per employee (in the trapped sector). In words, during disagreement the insider imposes the maximal cost on the firm (e.g. through strike, work-to-rule, sabotage) short of inducing dismissal. Assuming that disagreement in the current period does not affect future returns, the present values of insider's returns under disagreement is

wage agreements voluntarily, covering 52 percent of the remaining employees (Schnabel, 2005).

[164]This assumption is made merely for analytical convenience; various other assumptions would lead to similar results. The wage could e.g. be the outcome of a bargain between the firm and the marginal worker, or between the firm and a union representing all employees. In this last case, the insiders' objective in the bargain will depend on their retention rate.

[165]In what follows, only those variables have time subscripts that, for given parameter values, actually vary through time in our model. j is the index for the sector. It can either be P (primary sector) or T (trapped sector).

$$V'^{I}_{tr,t} = b_{tr,t} + \delta \begin{pmatrix} (1-\varpi)\left(1-\phi_{tr,t+1}\right) V^{I}_{tr,t+1} + (1-\varpi)\,\phi_{tr,t+1}\,(1-\varpi)\, V^{U}_{tr,t+1} \\ +\varpi\left(1-\phi_{pr,t+1}\right) V^{I}_{pr,t+1} + \varpi\phi_{pr,t+1} V^{U}_{pr,t+1} \end{pmatrix} \tag{217}$$

and the present value of the firm's agreement under disagreement is

$$\widetilde{\Pi}'_{tr,t} = -f_{tr,t} + \delta \begin{pmatrix} (1-\varpi)\left(1-\phi_{tr,t+1}\right) \widetilde{\Pi}^{I}_{tr,t+1} - (1-\varpi)\,\phi_{tr,t+1} f_{tr,t+1} \\ +\varpi\left(1-\phi_{pr,t+1}\right) \widetilde{\Pi}^{I}_{pr,t+1} - \varpi\phi_{pr,t+1} f_{pr,t+1} \end{pmatrix} \tag{218}$$

Thus the insider's bargaining surplus is

$$V^{I}_{tr,t} - V'^{I}_{tr,t} = w_{tr,t} - b_{tr,t} \tag{219}$$

and the firm's bargaining surplus is

$$\widetilde{\Pi}_{tr,t} - \widetilde{\Pi}^{I}_{tr,t} = a_{tr} - w_{tr,t} + f_{tr,t} \tag{220}$$

The negotiated wage maximizes the Nash product (Λ)

$$\Lambda = \left(w_{tr,t} - b_{tr,t}\right)^{\mu} \left(a^{I}_{tr} - w_{tr,t} + f_{tr,t}\right)^{1-\mu}, \tag{221}$$

where μ represents the bargaining strength of the insider relative to the firm. Thus the negotiated wage is

$$w_{tr,t} = (1-\mu)\, b_{tr,t} + \mu\left(a_{tr} + f_{tr,t}\right). \tag{222}$$

The bargaining problem is analogous in the primary sector (see Appendix), so that the negotiated primary wage is

$$w_{pr,t} = (1-\mu)\, b_{pr,t} + \mu\left(a_{pr} + f_{pr,t}\right). \tag{223}$$

6.2.2 Employment Decision

Having determined the wage, we now proceed to derive the hiring and firing rates for the primary and trapped sector.

Primary Sector: Given the realized value of the random cost variable ξ_t, which is iid across individuals and time and whose mean is normalized to zero, an insider generates the following present value of expected profit:[166]

$$\Pi_t = -\xi_t + \sum_{t=0}^{\infty} \delta^t \left(1-\phi_{pr}\right)^t (a_{pr} - w_{pr}) - \delta\phi_{pr} f_{pr} \sum_{t=0}^{\infty} \delta^t \left(1-\phi_{pr}\right)^t . \quad (224)$$

i.e. with probability $\left(1-\phi_{pr}\right)$ the insider is retained and generates profit $(a_{pr} - w_{pr})$, whereas with probability ϕ_{pr} is fired and generates the firing cost f_{pr} (constant per employee).

The insider is fired when her generated profit is less than the firing cost: $\Pi_t < -f_{pr}$, so that $\xi_t > (a_{pr} - w_{pr} + (1-\delta) f_{pr}) / \left(1-\delta\left(1-\phi_{pr}\right)\right)$. Recalling that $\Gamma(\xi_t)$ is the cumulative density of the random cost ξ_t, the firing rate is given by the following implicit function:[167]

$$\phi_{pr} = 1 - \Gamma\left(\frac{a_{pr} - w_{pr} + (1-\delta) f_{pr}}{1-\delta\left(1-\phi_{pr}\right)}\right) \quad (225)$$

The firm faces a hiring cost of h, constant per worker. An entrant is hired when his generated profit exceeds this hiring cost: $\Pi > h_{pr}$. Thus the hiring rate is

$$\eta_{pr} = \Gamma\left(\frac{a_{pr} - w_{pr} - \delta\phi_{pr} f_{pr}}{1-\delta\left(1-\phi_{pr}\right)} - h_{pr}\right) \quad (226)$$

The Trapped Sector: As noted, each worker in the trapped sector is assumed to have an average productivity a_{tr} that is lower than the one of his counterpart in the primary sector. Furthermore, trapped workers have a probability ϖ of moving into the primary sector. Thus, the present value of the profit generated by an entrant in the trapped sector is[168]

$$\begin{aligned} \Pi_t &= -\xi_t + \frac{a_{tr} - w_{tr} - \delta(1-\varpi)\phi_{tr} f_{tr}}{1-\delta(1-\phi_{tr})(1-\varpi)} - \phi_{pr}\delta\varpi \frac{f_{pr}}{(1-\delta(1-\varpi)(1-\phi_{tr}))} \\ &\quad + \left(1-\phi_{pr}\right)\delta\varpi\left(\frac{a_{pr} - w_{pr} - \delta\phi_{pr} f_{pr}}{\left(1-\delta\left(1-\phi_{pr}\right)\right)(1-\delta(1-\varpi)(1-\phi_{tr}))}\right) \end{aligned} \quad (227)$$

Along the same lines as before, a worker is fired if her expected profits are

[166] In what follows, only those variables have time subscripts that, for given parameter values, actually vary through time in our model.
[167] We assume that $(\partial\Gamma/\partial\phi) > -1$, so that a rise in $(a-w)$ or f both reduce the firing rate.
[168] See the Appendix for a detailed derivation.

smaller than minus the firing costs ($\Pi_t < -f_{tr}$):

$$\phi_{tr} = 1 - \Gamma \left(\begin{array}{c} \frac{a_{tr} - w_{tr} - \delta(1-\varpi)\phi_{tr} f_{tr}}{1-\delta(1-\phi_{tr})(1-\varpi)} + f_{tr} - \phi_{pr}\delta\varpi \frac{f_{pr}}{(1-\delta(1-\varpi)(1-\phi_{tr}))} \\ +\left(1-\phi_{pr}\right)\delta\varpi \left(\frac{a_{pr} - w_{pr} - \delta\phi_{pr} f_{pr}}{\left(1-\delta\left(1-\phi_{pr}\right)\right)(1-\delta(1-\varpi)(1-\phi_{tr}))} \right) \end{array} \right) \tag{228}$$

And she is hired if the expected profits are bigger than the hiring costs in the trapped sector ($\Pi_t > h_{tr}$).

$$\eta_{tr} = \Gamma \left(\begin{array}{c} \frac{a_{tr} - w_{tr} - \delta(1-\varpi)\phi_{tr} f_{tr}}{1-\delta(1-\phi_{tr})(1-\varpi)} - h_{tr} - \phi_{pr}\delta\varpi \frac{f_{pr}}{(1-\delta(1-\varpi)(1-\phi_{tr}))} \\ +\left(1-\phi_{pr}\right)\delta\varpi \left(\frac{a_{pr} - w_{pr} - \delta\phi_{pr} f_{pr}}{\left(1-\delta\left(1-\phi_{pr}\right)\right)(1-\delta(1-\varpi)(1-\phi_{tr}))} \right) \end{array} \right) \tag{229}$$

6.2.3 Employment Dynamics

We allow for the possibility that the employed workers in the trapped sector may raise their productivity - through learning-by-doing, improved work motivation, better work habits and so forth - and then move into the primary sector. Specifically, we also allow for the possibility that unemployed workers in the primary sector may lose productivity - through attrition of human capital, reduced work motivation, lost work habits, etc. - and then fall into the trapped sector. In particular, we assume that, in each period, a constant proportion ϖ of the employed workers in the trapped sector ascend to the primary sector, and a constant proportion υ of the unemployed primary workers descend into the trapped sector.

Thus, we obtain the following employment equation for the primary sector:[169]

$$N_{pr,t} = \left(1-\phi_{pr}\right) N_{pr,t-1} + \left(1-\phi_{pr}\right)\varpi N_{tr,t-1} + \eta_{pr}\left(1-\upsilon\right) U_{pr,t-1} \tag{230}$$

The employed in the primary sector ($N_{pr,t}$) consist of workers who are retained from the previous period[170] plus the newly hired workers ($\eta_{pr}\left(1-\upsilon\right) U_{pr,t-1}$).

For the trapped sector the employment dynamics equation is:

[169] Note that capital letters (N, U) refer to levels, while small letters (n, u) are (un-)employment rates.

[170] $(1-\phi_P) N_{P,t-1}$ are the primary employees carried forward from the previous period and $(1-\phi_P)\varpi N_{T,t-1}$ are the previously trapped workers who received a human capital upgrade.

$$N_{tr,t} = (1-\phi_{tr})(1-\varpi) N_{tr,t-1} + \eta_{tr}(U_{tr,t-1} + \upsilon U_{pr,t-1}) \tag{231}$$

The number of employed workers in the trapped sector equals those who are retained, without receiving a human capital upgrade, $((1-\phi_{tr})(1-\varpi) N_{tr,t-1})$ plus the newly hired workers $(\eta_{tr}(U_{tr,t-1} + \upsilon U_{pr,t-1}))$.[171]

After some re-formulations (see Appendix), we obtain an employment dynamics equation (expressed in employment rates) for the primary sector

$$\begin{aligned} n_{pr,t} &= \frac{1}{g_{t,pr}}\left[\left(1-\phi_{pr}\right) n_{pr,t-1} + \left(\eta_{pr}(1-\upsilon)\right)(1-n_{pr,t-1})\right] \\ &\quad + \left(1-\phi_{pr}\right)\varpi \frac{L_{tr,t-1}}{L_{pr,t}} n_{tr,t-1} \end{aligned} \tag{232}$$

and for the trapped sector

$$\begin{aligned} n_{tr,t} &= \frac{1}{g_{t,tr}}\left[(1-\phi_{tr})(1-\varpi) n_{tr,t-1} + \eta_{tr}(1-n_{tr,t-1})\right] \\ &\quad + \eta_{tr}\upsilon(1-n_{pr,t-1})\frac{L_{pr,t-1}}{L_{tr,t}} \end{aligned} \tag{233}$$

where L_{pr} and L_{tr} are the labor forces of the primary and secondary sector. $g_{t,pr} = L_{pr,t}/L_{pr,t-1}$ and $g_{t,tr} = L_{tr,t}/L_{tr,t-1}$ are the labor force growth in the primary and trapped sector.

The labor force in each sector is equal to the previous period's labor force plus the net movement from the other sector:

$$L_{pr,t} = L_{pr,t-1} - \upsilon u_{pr,t-1} L_{pr,t-1} + \varpi n_{tr,t-1} L_{tr,t-1} \tag{234}$$

and

$$L_{tr,t} = L_{tr,t-1} + \upsilon u_{pr,t-1} L_{pr,t-1} - \varpi n_{tr,t-1} L_{tr,t-1.} \tag{235}$$

Setting the sectoral growth rate to zero and omitting time subscripts, we obtain the following steady state value for the employment in the primary sector

[171] Note that the pool of potential recruits is enlarged by those who moved from the primary to the trapped sector $(\upsilon U_{t-1,P})$.

$$n_{pr}=\frac{\eta_{pr}\left(1-\upsilon\right)+\left(1-\phi_{pr}\right)\varpi\frac{\eta_{tr}\frac{L_{tr}}{L_{pr}}+\eta_{tr}\upsilon}{\left(1-\left[\left(1-\phi_{tr}\right)\left(1-\varpi\right)\right]+\eta_{tr}\right)}}{\phi_{pr}+\left(\eta_{pr}\left(1-\upsilon\right)\right)+\left(1-\phi_{pr}\right)\varpi\frac{\eta_{tr}\upsilon}{\left(1-\left[\left(1-\phi_{tr}\right)\left(1-\varpi\right)\right]+\eta_{tr}\right)}} \tag{236}$$

and in the trapped sector

$$n_{tr,t}=\frac{\eta_{tr}+\eta_{tr}\upsilon\left(1-n_{pr}\right)\frac{L_{pr}}{L_{tr}}}{\left(1-\left[\left(1-\phi_{tr}\right)\left(1-\varpi\right)\right]+\eta_{tr}\right)} \tag{237}$$

Logically, if we set $\upsilon=\varpi=0$, we have two entirely separated sectors in this economy and the above formula delivers the well-known formula:

$$n_{pr}=\frac{\eta_{pr}}{\phi_{pr}+\eta_{pr}} \text{ and } n_{tr}=\frac{\eta_{tr}}{\phi_{tr}+\eta_{tr}} \tag{238}$$

6.3 Calibration of the Model

In 2004, 17.2 percent of the East German full time employed workers were below the low wage income threshold, which is defined a two thirds of the East German median income, i.e. they earned below 7.36 € per hour (Rhein and Stamm, 2006). We consider these workers as a good proxy for the trapped sector. From Hunt (2004) we know that about 60 to 80 percent of unemployed in East Germany do not "survive" their first year of unemployment, i.e. they leave unemployment within one year, which we interpret as hiring. During the second year of unemployment the non-survival rate drops to much smaller numbers, roughly ranging in the magnitude of 20 to 50 percent (very much dependent on gender and observation period), with even smaller non-survival rates thereafter. It can be assumed that trapped workers represent a large share of the long-term unemployed since they have lower hiring rates and higher firing rates than primary workers. However, they do not do so exclusively, since primary workers in our model can stay unemployed for several periods without becoming employed and trapped (although the probability is decreasing over time). For simplicity, we set the steady state (indicated by the subscript $_0$) hiring rate for trapped workers ($\eta_{tr,0}$) to 30 percent and the one for primary workers to 80 percent ($\eta_{pr,0}$), roughly corresponding to Hunt's (2004) non-survival rates for long-term and short-term unemployed. In accordance with a transition table for the European Union (one year transition probability from "low pay" to "no pay", see European Commission, 2004), we set the steady state firing rate for trapped workers equal to $\phi_{tr,0}=0.18$. To obtain an aggregate employment rate of 80 percent[172], we set the steady state firing rate in the primary sector ($\phi_{pr,0}$) to 12 percent.

Furthermore, we have to choose an exogenous probability of an employed trapped worker to move to the trapped sector (ϖ). According to Rhein et al. (2005) the probability for German low wage income earners to move beyond the low income threshold after 5 years is 32.5 percent.[173] The European Commission (2004) calculates a probability of 50 percent for a low-pay worker to move to a higher pay within seven years.[174] In line with these two pieces of evidence, we set $\varpi = 0.08$. By setting the labor share of primary workers to 76 percent, about 17 percent of all employed workers belong to the trapped sector; thus corresponding to the numbers by Rhein and Stamm (2006). To obtain a stable initial equilibrium, we set the probability of a primary worker to move to the trapped sector (υ) to 11.2 percent.[175] In our initial equilibrium the unemployment rate in the primary sector is 12 percent, whereas it amounts to 35 percent in the trapped sector.

We set the replacement rates in the primary and trapped sector to 65 and 80 percent, respectively.[176] Aggregate real productivity (a, gross value added per worker) in 2005 was about €38,000 and real wages (w, measured as real labor costs) were about €22,000 in East Germany.[177] (All estimates are divided by the German GDP deflator, base year 1991.[178]). We set the productivity for trapped workers to 50 percent of the economy's average, while setting the one of primary workers to 110 percent of the average productivity.

Furthermore, we assume that in the long-run the productivity and all real costs (the wage, the hiring and firing costs and the operating cost ξ) grow at the same rate of two percent ($\zeta = 1.02$). All future values are discounted (δ) at rate 3%.[179]

In the literature firing costs (f_t) and hiring costs (h_t) which amount to 60

[172] This corresponds to the employment rate of dependently employed in East Germany (see Bundesagentur, 2006a, b).

[173] Corresponding to an average yearly probability of 7.6 percent.

[174] Corresponding to an average yearly probability of 9.4 percent.

[175] This is necessary to guarantee that the condition $\upsilon U_{NT} = \varpi N_T$ holds, i.e. in the old steady state the number of people moving from the trapped to the non-trapped sector equals those moving into the other direction.

[176] The net replacement ratios (unweighted average across six family types) of workers with 67, 100, and 150 percent of average productivity are 78.25, 68.25, and 64.67 percent, respectively (OECD, 2006).

[177] Source: Statistische Ämter des Bundes und der Länder (2006).

[178] This is done to make numbers comparable to chapter 5.

[179] This is the average real interest rate over last 15 years, calculated as the yearly money market interest rate minus the inflation rate (using the GDP deflator). Source: International Financial Statistics, International Monetary Fund.

percent and 10 percent of labor costs, respectively, are proposed (Chen and Funke, 2003). It is well known that the employment duration is one of the most important determinants of firing costs[180]. Thus, we set them to 40 percent for trapped workers, whose employment duration is shorter due to higher firing rates, and to 70 percent for primary workers. We assume that all workers have the same bargaining bargaining power is set equally for both sectors ($\mu = 0.195$) in order to match the aggregate labor costs in East Germany.

We simulate our model in a linearized form, choosing first derivatives of the cumulative function that replicate the employment path from 1991 to 2004 as closely as possible in the homogeneous model. (For the derivation of the linearized equations see Appendix.)

6.4 Policy Exercises

We now consider the effects of various labor policies in the context of our calibrated model of the East German labor market. We first examine the employment effects of policies targeted at the trapped sector, and then investigate untargeted policies. In both cases, we explore the influence of (i) a reduction of the ratio of the firing costs to the wage ("firing cost ratio") together with a fall in the replacement ratio[181], (ii) hiring subsidies, (iii) training subsidies that raise the probability of moving from the trapped to the primary sector. For the training subsidies the policy can of course only be targeted at trapped employees.

6.4.1 Policies Targeted at the Trapped Sector

Lower Replacement Rate and Firing Costs: Figure 3 shows the effects of a 5, 10 and 20 percent reduction of both the firing cost ratio (the ratio of firing costs to the wage) and the replacement ratio (the ratio of unemployment benefits to the wage) in the trapped sector, which both take place in period 0:

Steady state effects: A lower replacement ratio (RR) and a lower firing cost ratio (FCR) in the trapped sector affect the wage bargaining process. They change the fall-back position of both bargaining parties. As a consequence,

[180] See e.g. Grund (2006).

[181] In chapter 5 we have done several ex-post policy exercises with a model that did not contain traps. Especially during the last years of the observation period (1991-2004), our prediction was more optimistic than the real outcome, suggesting the existence of labor market traps. The first policy exercise is the same as in chapter 5, but the innovation of this paper over chapter 5 is that it models the effects of labor market traps. It turns out that they have far-reaching implications for the effectiveness of employment policies, as shown below.

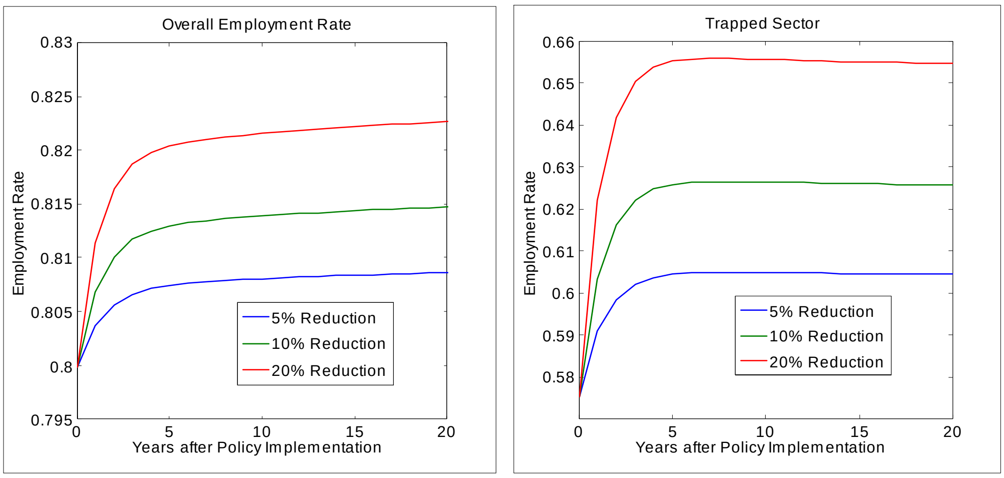


Figure 23: Effects of a FCR and RR reduction in the trapped sector

insiders bid for lower wages. This improves firms' incentives to hire and retain more of the less productive workers and thus to increase their long-run employment rate in the trapped sector. A 20 percent reduction of the replacement ratio and firing cost ratio[182] makes wages fall to about two thirds of their initial steady state value. But this considerable reduction lifts the trapped sector's employment rate only from 58 percent to 65 percent. The reason can be found in the microfounded hiring and firing equations. Since trapped workers face a higher steady state firing rate, the expected future profits of an employed worker in the trapped sector is smaller than in the primary sector. For given operating costs this leads to smaller hiring and hiring sensitivities with respect to wage changes.

There are two reasons why the effects on the overall employment rate are quite moderate: (i) The trapped sector contains only a small share of all workers (24 percent). (ii) Only some of the newly hired workers obtain a human capital upgrade which leads to a higher employment rate, while most of the newly hired trapped workers face a high risk of being fired (compared to primary sector workers). In the long-run a 20 percent reduction of the replacement ratio and firing cost ratio in the trapped sector only reduces the share of trapped workers from 24 to 22 percent.

As a consequence, a 20 percent reduction of the replacement ratio and firing cost ratio (inducing a wage reduction to two thirds of the initial value) in the trapped sector increases the overall long-run employment rate only by

[182] Note that in the trapped sector wages react more sensitively to cuts in the replacement rate and firings costs than in the primary sector.

2 percentage points. *This very insensitive reaction may explain why the recent reduction of the wages in East Germany (compared to the productivity) did not have much of an effect on the employment rate (see figure (18)).*[183]

Adjustment dynamics: The increased hiring rate and reduced firing rates do not only lift the employment rate in the trapped sector. With more employed people and an exogenously given probability to move from the trapped to the primary sector, the sectoral upward movement increases. It takes a long time until this development shows its full effects: For a 20 percent reduction of the replacement ratio and the firing cost ratio, 90 percent of the convergence to the new steady state are realized only after 10 years.

If the replacement ratio of the most unemployment-prone group is reduced (the trapped unemployed), the described policy comes at the price of increased income inequality (between high income and low income earners). While this policy may help some trapped workers who would not have found a job otherwise and who get a chance to move to the primary sector, it hurts the insiders in the trapped sector who obtain a lower wage and the trapped workers who remain unemployed and receive lower unemployment benefits (due to lower unemployment benefits).[184]

Hiring Subsidies: Figure 4 shows the employment effects of a hiring subsidy which is targeted at the trapped sector with different magnitudes (50, 75 and 100 percent of the respective wage).

Steady state effects: A hiring subsidy for trapped workers increases the firms' incentive to hire more workers with lower productivity. Other than in a homogenous economy, hiring subsidies deliver a double dividend. Besides the immediate hiring effects, there is a longer lasting "transition effect," caused by the inter-sectoral movement. The increased employment rate strengthens the upward mobility to the primary sector. A hiring subsidy of 100 percent would for example reduce the share of trapped workers (of the overall workforce) from 24 to 22.5 percent.

Adjustment dynamics: The after effects of the increased movement to the primary sector take some time to work themselves out: for a 100 percent hiring subsidies, 90 percent of the distance to the new steady state is reached after 12 years.

[183] Note that the reduction of the employment rate at the beginning and middle of the ninenties can easily be explained by the initial wage shock. However, it is more difficult to explain the development during the last ten years.

[184] See chapter 7 for a more detailed analysis of the inequality effects of different policies.

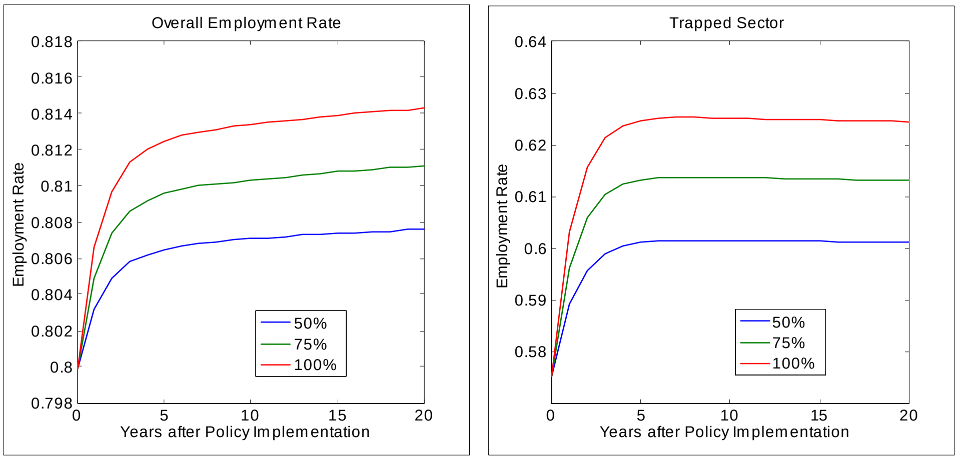


Figure 24: Effects of a hiring subsidy in the trapped sector

If hiring subsidies are targeted at trapped workers only (as done in the simulation), they are much more cost-effective[185] than an untargeted strategy: (i) the deadweight is much lower since the initial steady state hiring rates in the trapped sector are below those in the primary sector, (ii) the replacement ratio of trapped workers is above those of primary workers and thus the savings (in terms of the respective wage) generated by the job creation are much bigger, (iii) the aforementioned "transition effect" strengthens the overall outcome.

Hiring subsidies need to be financed. According to our simulation, long-run net expenditures caused by a 100 percent hiring subsidy[186] for all trapped workers are about the same as the long-run net savings generated by a 7 percent reduction of the firing cost ratio and replacement ratio.[187]

Hiring subsidies increase employment, without worsening the living standard of the poorest workers, namely the unemployed trapped workers (since they continue to receive the same benefits as before). As a consequence, it may be easier from a political economy point of view to implement hiring subsidies than reducing the replacement ratio, which makes the unemployed workers worse off.

Training Measures: Training subsidies or other measures that improve job-related training (e.g. on the job training, qualification courses, training measures, etc.), could improve trapped workers' productivity and consequently

[185] Defined as employment effect for a given additional government expenditure.
[186] Of the labor costs in the trapped sector.
[187] This calculation is based on an average tax rate of 20 percent and the aforementioned net replacement rates.

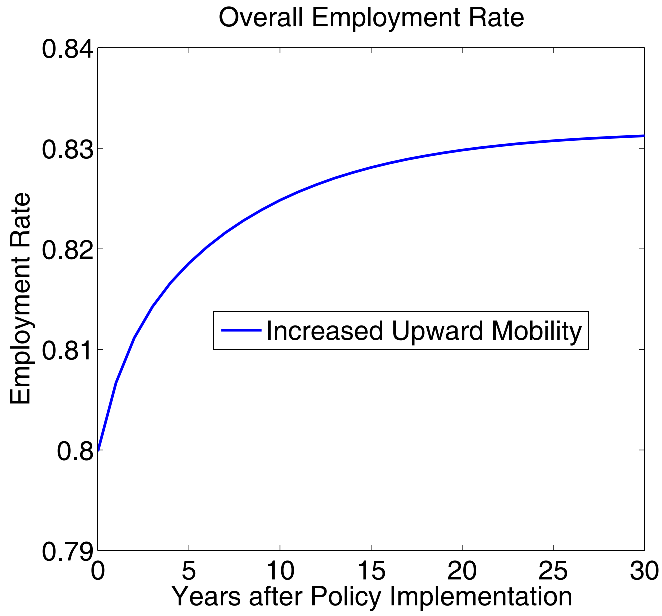


Figure 25: Effects of training subsidies

their access to primary good. In our model, better training measures can be captured in terms of an increase in the exogenously given probability of moving from the trapped to the primary sector (ϖ). Figure 5 shows what happens if the probability of moving from the trapped to the primary sector increases from 8 to 16 percent. The latter number roughly corresponds to a rate found in many other European Union countries, such as Belgium, Denmark, France, Italy the Netherlands or Spain (European Commission, 2004).

Steady state effects: The training measures above raise the economy's overall steady state employment rate by moving more people to the primary sector which is associated with higher employment rates. Naturally, the steady state employment rate of the trapped sector does not increase, as only the intersectoral mobility is affected but not the sectoral hiring and firing rates. Thus, better training measures change the share of workers in the respective sectors. The aforementioned policy would increase the share of primary workers from 74 to 86.5 percent.

Adjustment dynamics: It takes a very long time until such a policy shows its full effects. In our model 90 percent of the distance to the new steady state would be reached 17 years after the implementation of the policy.

Furthermore, in reality it will be a challenge to design training measures in a way that they can effectively improve workers' upward mobility (for empirical work for East Germany see, for example, Lechner, Miquel and Wunsch, 2005, and Lechner and Wunsch, 2007).

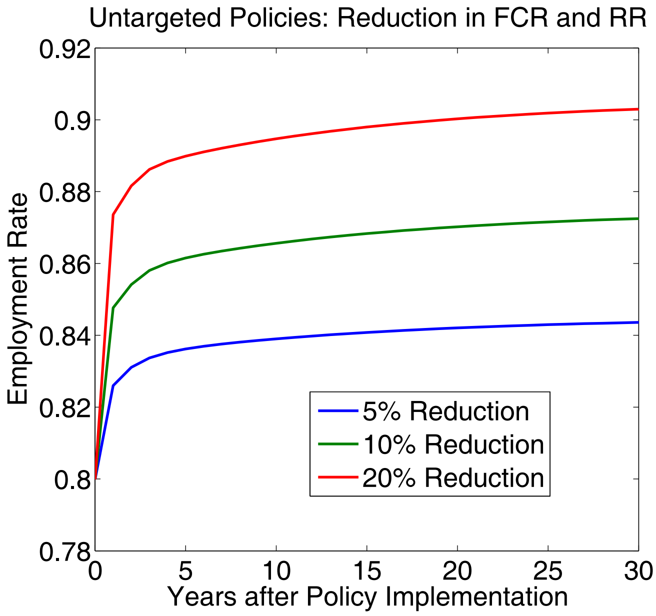


Figure 26: Effects of an untargeted reduction of the FCR and the RR

6.4.2 Untargeted Policies

Reduction of Unemployment Benefits and Firing Cost Ratio: If the unemployment benefits and firing cost ratio are reduced for all workers (not just for those in the trapped sector), the employment effects will be modified as follows:

(i) The primary sector's hiring rate increases and the firing rate decreases, as firms' obtain an incentive to hire/retain more of the less productive workers.

(ii) While a higher employment rate in the primary sector is reached quickly, there are long-lasting aftereffects through the intersectoral movement of labor. A lower unemployment rate in the primary sector means that fewer people drop into the trapped sector and thus the trapped sector shrinks compared to the primary sector. While a 20 percent cut in unemployment benefits and firing cost ratio for in the trapped sector only would increase the primary sector's share labor share from 76 to 78 percent, extending the policy to the entire economy would increase the primary sector's labor share from 78 to 88 percent.

(iii) If the firing rate in the primary sector goes down, there is a positive spillover effect on the hiring and firing rates in the trapped sector (see equations (228) and (229)). Since trapped workers have a constant probability of getting a human capital upgrade in the future, higher retention rates in the primary sector increase these workers' profitability, giving an incentive to firms to retain/hire more of the less productive workers.

Hiring Subsidies: In this section we compare untargeted hiring subsidies (provided to all workers) to those targeted at the trapped sector (as described in the previous section). Providing a 100 percent hiring subsidy[188] to all workers (instead of trapped workers only) would roughly double the employment effects which are shown in the previous section. However, such an exercise would come at a substantial cost to the government. Specifically, the net costs[189] of such an untargeted strategy would be about 9 times higher than those for a 100 percent hiring subsidy targeted at trapped unemployed. The main reason is the very substantial deadweight effect because the hiring rates in the primary sector are much bigger than in the trapped sector.

6.4.3 Summary of Calibration Results

Kick-Starting East Germany: Our calibration exercise shows that even very significant wage reductions in the trapped sector (induced by reductions in the respective replacement ratio and the firing cost ratio) would not be sufficient to bring East Germany to employment levels comparable to West Germany.[190] If the replacement ratio and firing cost ratio are reduced in the primary sector as well, this does not only make primary workers more profitable for firms, but also improves the average profitability of the trapped workers (each of them receives a human capital upgrade with a certain probability). Consequently, the employment rate in the trapped sector will rise. Furthermore, the lower unemployment rate in the primary sector will reduce the workers who move to the trapped sector, thus increasing the economy's ratio of primary to trapped workers. Our calibration shows that these spillover effects are very important. Reductions of the replacement ratio and firing cost ratio for all workers can improve the employment rate in the trapped sector and in the economy as a whole much more than a policy that is focused on trapped workers.

While an untargeted strategy is more effective for the reduction of the replacement ratio and firing cost ratio, the opposite is true for hiring subsidies. If they are targeted at the trapped sector, they turn out to be more cost

[188] Measured in terms of the respective wage.

[189] Defined as the costs for the hiring subsidy minus the increased revenue from higher employment (via higher tax revenues with an assumed tax rate of 20 percent and lower costs for unemployment benefits) in the new steady state.

[190] This result differs very much from chapter 5 where it is shown in a labor market model without traps that very moderate reforms would have had substantial positive effects.

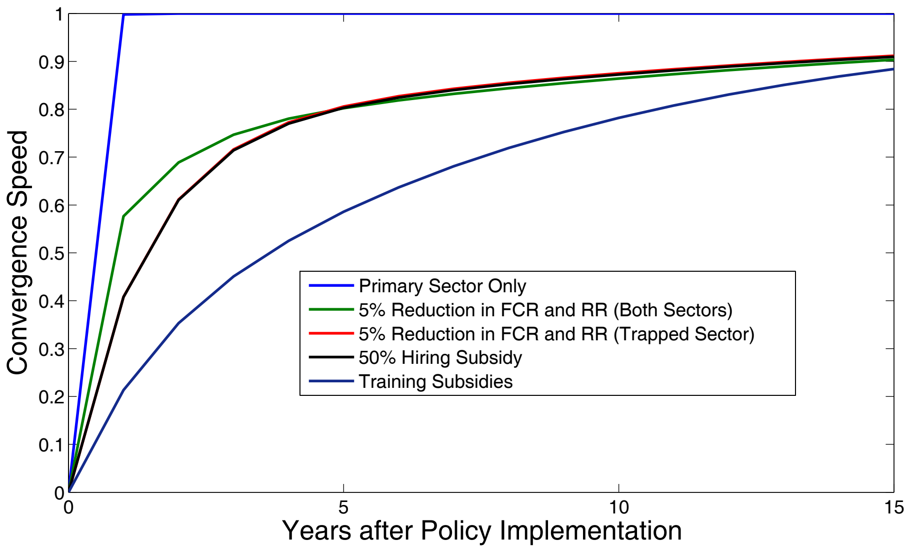


Figure 27: Convergence speed of different policies

effective than untargeted hiring subsidies, for the following reasons. In the presence of traps, hiring subsidies yield a double dividend of increased hiring and transition to the primary sector. Furthermore, the associated deadweight in the trapped sector is much smaller than in the primary sector. As shown in our calibration, the net budgetary outlay for an targeted subsidy is one ninth as high as the one for an untargeted hiring subsidy, while it delivers one half of the overall the employment effects.

Training measures improve the prospects of trapped workers and thus lift the economy's employment rate in the long-run. But it takes a long time until they show their full effects.

As shown above, a moderate cut in the replacement ratio and a reduction of the firing cost ratio can be combined with a substantial hiring subsidy in a self-financing policy package. Together with improved training measures these labor market policies would help the East to become somewhat more independent of the "caring hand that cripples" (Snower and Merkl, 2006).

General Lessons for Regional Unemployment Problems: The behavior of the dual labor market, with a primary and a trapped sector differs in two substantial respects from a homogenous labor market:

(i) As shown above, even very substantial reductions in the replacement ratio and the firing cost ratio are not sufficient to reduce the unemployment ratio in the trapped sector to rates which can usually be observed in continental

European countries, say around 10 percent.

(ii) The effects of different labor market policies are much more persistent under a dual labor market than under a homogenous labor market. We illustrate this phenomenon in figure (27). It takes at least a decade for policies like the reduction of the replacement ratio and firing cost ratio or hiring subsidies to show 90 percent of their after effects. Training subsidies need even more time to show 90 percent of their full after effects. For a comparison: In an economy which only consists of the primary sector, almost the whole effects of labor market reforms would already be visible after one year ("Primary Sector Only").

6.5 Concluding Thoughts

The chapter explains a puzzling aspect of regional employment and unemployment differentials, namely that they are very persistent despite changes in wages relative to productivity. Therefore, we develop a dual labor market model with a primary and trapped sector. We show numerically that the trapped sector of the economy, which faces an enormous unemployment rate, reacts very sluggishly to reductions of the wage. We propose additional measures to leave the trap, namely hiring subsidies and better training schemes.

East Germany is simply an extreme example of this phenomenon, which also exists in Spain and Italy and elsewhere. This phenomenon makes the inequality across regions especially persistent and policy makers have been at a loss about how to treat this problem. This chapter provides new insights on which policies are useful and effective under these circumstances and on potential trade-offs which policy makers face.

6.6 Technical Appendix

6.6.1 Wage Bargaining

Bargaining in the Primary Sector: The expected present value of returns to a primary insider under bargaining agreement $\left(V_{pr,t}^{I}\right)$ is

$$V_{pr,t}^{I} = w_{pr,t} + \delta\left(\left(1-\phi_{pr,t+1}\right)V_{pr,t+1}^{I} + \left(1-\phi_{pr,t+1}\right)V_{pr,t+1}^{U}\right) \tag{239}$$

where δ is the discount factor and $V_{pr,t+1}^{U}$ is the expected present value of returns of an unemployed primary worker and $V_{pr,t+1}^{I}$ is the expected present value of returns of an employed primary worker. The expected present value of returns to the firm under bargaining agreement is

$$\widetilde{\Pi}'_{pr,t} = \left(a_{pr} - w_{pr,t}\right) + \delta\left(\left(1-\phi_{pr,t+1}\right)\widetilde{\Pi}_{pr,t+1}^{I} - \phi_{pr,t+1}f_{pr,t+1}\right) \tag{240}$$

where $\widetilde{\Pi}_{pr,t+1}^{I}$ is the future profit in the primary.

Under disagreement, the insider's fallback income is $b_{pr,t}$, assumed equal to the unemployment benefit. The firm's fallback profit is $-f_{pr,t}$, which is the firing cost per employee (in the trapped sector). Assuming that disagreement in the current period does not affect future returns, the present values of insider's returns under disagreement is

$$V_{pr,t}^{\prime I} = b_{pr,t} + \delta\left(\left(1-\phi_{pr,t+1}\right)V_{pr,t+1}^{I} + \left(1-\phi_{pr,t+1}\right)V_{pr,t+1}^{U}\right) \tag{241}$$

and the present value of the firm's agreement under disagreement is

$$\widetilde{\Pi}'_{pr,t} = -f_{pr,t} + \delta\left(\left(1-\phi_{pr,t+1}\right)\widetilde{\Pi}_{pr,t+1}^{I} - \phi_{pr,t+1}f_{pr,t+1}\right) \tag{242}$$

Thus the insider's bargaining surplus is

$$V_{pr,t}^{I} - V_{pr,t}^{\prime I} = w_{pr,t} - b_{pr,t} \tag{243}$$

and the firm's bargaining surplus is

$$\widetilde{\Pi}_{pr,t} - \widetilde{\Pi}_{pr,t}^{I} = a_{pr} - w_{pr,t} + f_{pr,t} \tag{244}$$

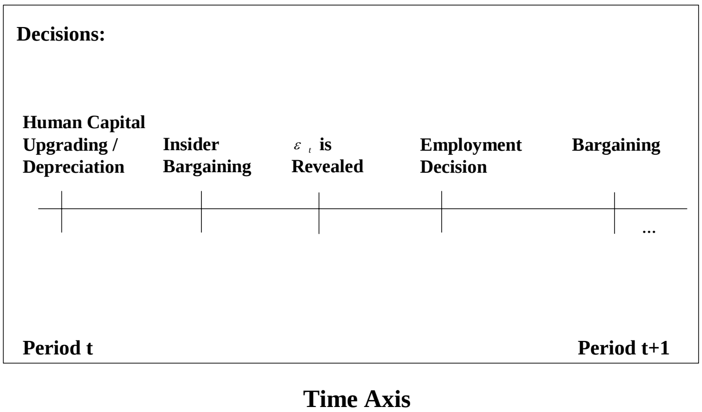


Figure 28: Sequencing of decisions

The negotiated wage maximizes the Nash product (Λ)

$$\Lambda = (w_{pr,t} - b_{pr,t})^{\mu} \left(a_{pr}^{I} - w_{pr,t} + f_{pr,t}\right)^{1-\mu}. \tag{245}$$

Thus:

$$w_{pr,t} = (1-\mu)\, b_{pr,t} + \mu\,(a_{pr} + f_{pr,t})\,. \tag{246}$$

Further Assumptions: We assume that the firing costs are proportional to the wage $f_{i,t} = \rho_{i,t} w_{i,t}$ (where i is the index for primary (pr) and trapped (tr) workers) with the "firing cost ratio" $\rho_{i,t}$ in the respective sectors and that the unemployment benefit in our model is given by $b_{i,t} = rr_{i,t} w_{i,t}$ with the net replacement ratio $rr_{i,t}$ in the respective sectors. Thus, the negotiated wage is

$$w_{i,t} = \frac{\mu}{(1 - rr_{i,t}(1-\mu) - \rho\mu)} a_{i,t}\ . \tag{247}$$

6.6.2 Model Derivation

Profit in the Trapped Sector In the trapped sector, workers have an average productivity a_{tr} and there is an exogenously given probability ϖ for employed workers to move to the primary sector of the economy. Firms take the regime switch into account (upgrade of trapped to primary workers), which

State	Probability
Human Capital Upgrading	ϖ
No Upgrading + Firing	$(1-\varpi)\,\phi_{tr}$
No Upgrading + Retention	$(1-\varpi)\,(1-\phi_{tr})$

Table 7: Human capital upgrade

increases the profitability.

The profit function below ($\Pi_{t,regime1}$) corresponds to the first regime (average profits weighted with the probability that workers stay trapped):

$$\begin{aligned} \Pi_{t,regime1} &= -\xi_t + \sum_{t=0}^{\infty} \delta^t (1-\phi_{tr})^t (1-\varpi)^t (a_{tr} - w_{tr}) - \\ &\quad (1-\varpi)\,\delta\phi_{tr} f_{tr} \sum_{t=0}^{\infty} \delta^t (1-\varpi)^t (1-\phi_{tr})^t \end{aligned} \tag{248}$$

$$\Pi_{t,regime1} = \frac{a_{tr} - w_{tr} - \delta(1-\varpi)\,\phi_{tr} f_{tr}}{1-\delta(1-\phi_{tr})(1-\varpi)} \tag{249}$$

In each subsequent period a worker moves with probability ϖ from the trapped to the primary sector. The profit function below ($\Pi_{t,regime2}$) corresponds to the second regime:

$$\begin{aligned} \Pi_{t,regime2} &= \delta\varpi \sum_{t=0}^{\infty} \delta^t (1-\varpi)^t (1-\phi_{tr})^t \\ &\left[\begin{array}{c} -\phi_{pr} f_{pr} + \\ (1-\phi_{pr}) \left(\begin{array}{c} \sum_{t=0}^{\infty} \delta^t \left(1-\phi_{pr}\right)^t (a_{pr} - w_{pr}) - \\ \delta\phi_{pr} f_{pr} \sum_{t=0}^{\infty} \delta^t \left(1-\phi_{pr}\right)^t \end{array} \right) \end{array} \right] \end{aligned} \tag{250}$$

The second line of the formula describes the present value of a worker if she is upgraded to the primary sector. An upgraded primary worker has the probability ϕ_{pr} of not being fired immediately and a probability $\left(1-\phi_{pr}\right)$ of being retained. If the latter is the case, she has the same expected profit stream as a primary workers: $\sum_{t=0}^{\infty} \delta^t \left(1-\phi_{pr}\right)^t (a_{pr} - w_{pr}) - \delta\phi_{pr} f \sum_{t=0}^{\infty} \delta^t \left(1-\phi_{pr}\right)^t$. Since every period a certain fraction of workers moves the primary sector, we have to write a double sum. A fraction ϖ among those who have not been fired $(1-\varpi)^t (1-\phi_{tr})^t$ moves to the primary sector.

$$\Pi_{t,regime2} = \delta\varpi \sum_{t=0}^{\infty} \delta^t (1-\varpi)^t (1-\phi_{tr})^t \left[-\phi_{pr} f_{pr} + \left(1-\phi_{pr}\right) \left(\frac{a_{pr} - w_{pr} - \delta\phi_{pr} f_{pr}}{1-\delta\left(1-\phi_{pr}\right)} \right) \right] \quad (251)$$

$$\Pi_{t,regime2} = -\phi_{pr}\delta\varpi \frac{f_{pr}}{(1-\delta(1-\varpi)(1-\phi_{tr}))} + \left(1-\phi_{pr}\right)\delta\varpi \left(\frac{a_{pr} - w_{pr} - \delta\phi_{pr} f_{pr}}{\left(1-\delta\left(1-\phi_{pr}\right)\right)(1-\delta(1-\varpi)(1-\phi_{tr}))} \right) \quad (252)$$

Thus, the overall expected profit ($\Pi_t = \Pi_{t,regime1} + \Pi_{t,regime2}$) is:

$$\Pi_t = -\xi_t + \frac{a_{tr} - w_{tr} - \delta(1-\varpi)\phi_{tr} f_{tr}}{1-\delta(1-\phi_{tr})(1-\varpi)} - \phi_{pr}\delta\varpi \frac{f_{pr}}{(1-\delta(1-\varpi)(1-\phi_{tr}))} + \left(1-\phi_{pr}\right)\delta\varpi \left(\frac{a_{pr} - w_{pr} - \delta\phi_{pr} f_{pr}}{\left(1-\delta\left(1-\phi_{pr}\right)\right)(1-\delta(1-\varpi)(1-\phi_{tr}))} \right) \quad (253)$$

Employment Dynamics:

Primary Sector: The (primary) employment in period t is equal to the people who are retained, both from the pool of employed ($N_{pr,t-1}$) and from the human capital upgrades ($\varpi N_{tr,t-1}$). The two groups have the same retention probability $1-\phi_{pr}$. A proportion η_{pr} of the unemployed primary workers is hired. The pool of primary unemployed workers is reduced by a share υ (workers who move to the trapped sector).

$$N_{pr,t} = \left(1-\phi_{pr}\right) N_{pr,t-1} + \left(1-\phi_{pr}\right)\varpi N_{tr,t-1} + \eta_{pr} U_{pr,t-1} - \eta_{pr}\upsilon U_{pr,t-1} \quad (254)$$

$$N_{pr,t} = \left(1-\phi_{pr}\right) N_{pr,t-1} + \left(1-\phi_{pr}\right)\varpi N_{tr,t-1} + \left(\eta_{pr}(1-\upsilon)\right) U_{pr,t-1} \quad (255)$$

Next, we introduce $g_{t,pr}$ which is the growth rate of the primary workforce from period $t-1$ to t ($g_{t,pr} = L_{pr,t}/L_{pr,t-1}$).

Dividing by $L_{pr,t}$, we obtain:

$$\begin{aligned} n_{pr,t} &= \frac{1}{g_{t,pr}}\left(1-\phi_{pr}\right)n_{pr,t-1}+\left(1-\phi_{pr}\right)\varpi\frac{N_{tr,t-1}}{L_{pr,t}}+ \\ &\quad \frac{1}{g_{t,pr}}\left(\eta_{pr}\left(1-\upsilon\right)\right)\left(1-n_{pr,t-1}\right) \end{aligned} \tag{256}$$

$$\begin{aligned} n_{pr,t} &= \frac{1}{g_{t,pr}}\left[\left(1-\phi_{pr}\right)n_{pr,t-1}+\left(\eta_{pr}\left(1-\upsilon\right)\right)\left(1-n_{pr,t-1}\right)\right] \\ &\quad +\left(1-\phi_{pr}\right)\varpi\frac{L_{tr,t-1}}{L_{pr,t}}n_{tr,t-1}. \end{aligned} \tag{257}$$

The labor force in the primary sector is equal to the previous period's labor force plus the net movement from the trapped sector:

$$L_{pr,t} = L_{pr,t-1} - \upsilon u_{pr,t-1}L_{pr,t-1} + \varpi n_{tr,t-1}L_{tr,t-1}. \tag{258}$$

In the steady state, the growth rate of the labor force is equal to 0 ($g_{t,pr} = L_{pr,t}/L_{pr,t-1} = 1$) and all time indices can be dropped. Thus, the following equation holds:

$$n_{pr}\left(\phi_{pr}+\left(\eta_{pr}\left(1-\upsilon\right)\right)\right) = \left(1-\upsilon\right)\eta_{pr}+\varpi\left(1-\phi_{pr}\right)n_{tr}\frac{L_{tr}}{L_{pr}}. \tag{259}$$

And the following constraint (human capital upgrades must equal downgrades) has to hold in the steady state:

$$\upsilon U_{pr} = \varpi N_{tr} \tag{260}$$

Trapped Sector: The employed in the trapped sector equal the retained workers from the previous period (who did not receive a human capital upgrade: $\left(1-\varpi\right)N_{tr,t-1}$) plus the hired trapped unemployed (their number has been enlarged by the human capital depreciation: $\eta_{tr}U_{tr,t-1}+\eta_{tr}\upsilon U_{pr,t-1}$):

$$N_{tr,t} = \left(1-\phi_{tr}\right)\left(1-\varpi\right)N_{tr,t-1}+\eta_{tr}U_{tr,t-1}+\eta_{tr}\upsilon U_{pr,t-1} \tag{261}$$

Dividing by $L_{tr,t}$:

$$n_{tr,t} = \frac{1}{g_{t,tr}} \left[(1-\phi_{tr})(1-\varpi) n_{tr,t-1} + \eta_{tr} (1-n_{tr,t-1}) \right] + \eta_{tr} \upsilon \frac{U_{pr,t-1}}{L_{tr,t}} \tag{262}$$

$$\begin{aligned} n_{tr,t} &= \frac{1}{g_{t,tr}} \left[(1-\phi_{tr})(1-\varpi) n_{tr,t-1} + \eta_{tr} (1-n_{tr,t-1}) \right] + \\ & \eta_{tr} \upsilon (1-n_{pr,t-1}) \frac{L_{pr,t-1}}{L_{tr,t}} \end{aligned} \tag{263}$$

The labor force in the trapped sector is equal to the previous period's labor force plus the net movement from the primary sector:

$$L_{tr,t} = L_{tr,t-1} + \upsilon u_{pr,t-1} L_{pr,t-1} - \varpi n_{tr,t-1} L_{tr,t-1.} \tag{264}$$

In the steady state the following relationship holds:

$$n_{tr} = (1-\phi_{tr})(1-\varpi) n_{tr} + \eta_{tr}(1-n_{tr}) + \eta_{tr}\upsilon(1-n_{pr}) \frac{L_{pr}}{L_{tr}} \tag{265}$$

$$n_{tr,t} = \frac{\eta_{tr} + \eta_{tr}\upsilon(1-n_{pr})\frac{L_{pr}}{L_{tr}}}{(1-(1-\phi_{tr})(1-\varpi)+\eta_{tr})}. \tag{266}$$

Inserting (266) into (259), we obtain the following steady state relationship:

$$\begin{aligned} & n_{pr}\left(\phi_{pr} + \left(\eta_{pr}(1-\upsilon)\right)\right) \\ = \; & \eta_{pr}(1-\upsilon) + \left(1-\phi_{pr}\right)\varpi \frac{\eta_{tr} + \eta_{tr}\upsilon(1-n_{pr})\frac{L_{pr}}{L_{tr}}}{(1-(1-\phi_{tr})(1-\varpi)+\eta_{tr})} \frac{L_{tr}}{L_{pr}} \end{aligned} \tag{267}$$

$$n_{pr} = \frac{\eta_{pr}(1-\upsilon) + \left(1-\phi_{pr}\right)\varpi \frac{\eta_{tr}\frac{L_{tr}}{L_{pr}} + \eta_{tr}\upsilon}{(1-(1-\phi_{tr})(1-\varpi)+\eta_{tr})}}{\phi_{pr} + \left(\eta_{pr}(1-\upsilon)\right) + \left(1-\phi_{pr}\right)\varpi \frac{\eta_{tr}\upsilon}{(1-(1-\phi_{tr})(1-\varpi)+\eta_{tr})}}. \tag{268}$$

If $\upsilon = \varpi = 0$, we have two entirely separated sectors in this economy and we obtain the following steady state relationship:

$$n_{pr} = \frac{\eta_{pr}}{\phi_{pr} + \eta_{pr}}. \tag{269}$$

6.6.3 Derivations for the Calibration

Non-Trapped Sector: The detailed derivations of the steady state firing and hiring rates under different policy exercises is analogous to Chapter 5[191], providing the following linearized equations:

$$\begin{aligned}\phi_{pr,new} &= \phi_{pr,0} - A_{pr}\left[(a_{pr,new} - w_{pr,new}) - (a_{pr,0} - w_{pr,0})\right] \\ &\quad - C_{pr}\left(f_{pr,new} - f_{pr,0}\right)\end{aligned} \tag{270}$$

and

$$\begin{aligned}\eta_{pr,new} &= \eta_{pr,0} + G_{pr}\left[(a_{pr,new} - w_{pr,new}) - (a_{pr,0} - w_{pr,0})\right] \\ &\quad - I_{pr}\begin{pmatrix} f_{pr,new} \\ -f_{pr,0}\end{pmatrix} - K_{pr}\begin{pmatrix} h_{pr,new} \\ -h_{pr,0}\end{pmatrix} - L_{pr}\begin{pmatrix} \phi_{pr,new} \\ -\phi_{pr,0}\end{pmatrix},\end{aligned} \tag{271}$$

where all coefficients A_{pr} to L_{pr} have a positive sign.

Trapped Sector:

Firing Rate: A worker is fired if $\Pi_t < -f_{tr}$.

$$\phi_{tr} = 1 - \Gamma\left(\begin{array}{c} \frac{a_{tr} - w_{tr} - \delta(1-\varpi)\phi_{tr} f_{tr}}{1-\delta(1-\phi_{tr})(1-\varpi)} + f_{tr} - \phi_{pr}\delta\varpi\frac{f_{pr}}{(1-\delta(1-\varpi)(1-\phi_{tr}))} \\ + \left(1-\phi_{pr}\right)\delta\varpi\left(\frac{a_{pr} - w_{pr} - \delta\phi_{pr} f_{pr}}{\left(1-\delta\left(1-\phi_{pr}\right)\right)(1-\delta(1-\varpi)(1-\phi_{tr}))}\right)\end{array}\right) \tag{272}$$

For the calibration we deflate all variables to their 1991 real value (using German GDP deflator[192]) and take into account a 2% ($\zeta = 1.02$) growth rate of all variables (a, w, f) and the operating costs to make the calibration more realistic and comparable to chapter 5.

$$\phi_{tr} = 1 - \Gamma\left(\frac{1}{\zeta^{15}}\left(\begin{array}{c} \frac{a_{tr} - w_{tr} - \delta\zeta(1-\varpi)\phi_{tr} f_{tr}}{1-\delta\zeta(1-\phi_{tr})(1-\varpi)} + f_{tr} - \phi_{pr}\delta\zeta\varpi\frac{f_{pr}}{(1-\delta\zeta(1-\varpi)(1-\phi_{tr}))} \\ + \left(1-\phi_{pr}\right)\delta\zeta\varpi\left(\frac{a_{pr} - w_{pr} - \delta\zeta\phi_{pr} f_{pr}}{\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)(1-\delta\zeta(1-\varpi)(1-\phi_{tr}))}\right)\end{array}\right)\right) \tag{273}$$

[191] See page 39 of the detailed version.

[192] Source: International Financial Statistics, International Monetary Fund.

Next, we take a first order Taylor approximation for the firing rate (where the subscript "0" refers to old steady state values and the subscript "new" refers to new steady state values). Therefore, we need the first derivatives at the old steady state with respect to the following variables:

$$\frac{\partial \phi_{tr,0}}{\partial \left(a_{tr} - w_{tr}\right)} = -\frac{1}{\zeta^{15}}\Gamma'_{f,0}\left[\frac{1}{1-\zeta\delta\left(1-\phi_{tr}\right)\left(1-\varpi\right)}\right]_0 \tag{274}$$

$$\frac{\partial \phi_{tr,0}}{\partial \left(a_{pr} - w_{pr}\right)} = -\frac{1}{\zeta^{15}}\Gamma'_{f,0}\left[\frac{\left(1-\phi_{pr}\right)\delta\zeta\varpi}{\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right)}\right] \tag{275}$$

$$\frac{\partial \phi_{tr,0}}{\partial f_{tr}} = -\frac{1}{\zeta^{15}}\Gamma'_{f,0}\left[\frac{-\delta\zeta\phi_{tr}\left(1-\varpi\right)}{1-\zeta\delta\left(1-\phi_{tr}\right)\left(1-\varpi\right)}+1\right]_0 \tag{276}$$

$$\frac{\partial \phi_{tr,0}}{\partial f_{pr}} = -\frac{1}{\zeta^{15}}\Gamma'_{f,0}\left[\begin{array}{c} -\frac{\delta\zeta\varpi\phi_{pr}}{\left(1-\delta\zeta(1-\varpi)(1-\phi_{tr})\right)} \\ -\frac{\delta^2\zeta^2\varpi\phi_{pr}\left(1-\phi_{pr}\right)}{\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta(1-\varpi)(1-\phi_{tr})\right)} \end{array}\right]_0 \tag{277}$$

$$\frac{\partial \phi_{tr,0}}{\partial \phi_{tr}} = -\frac{1}{\zeta^{15}}\Gamma'_{f,0}\left[\begin{array}{c} \left(\frac{\begin{array}{c} -\delta\zeta f_{tr}\left(1-\varpi\right)\left(1-\delta\zeta\left(1-\phi_{tr}\right)\left(1-\varpi\right)\right) - \\ \delta\zeta\left(1-\varpi\right)\left[a_{tr}-w_{tr}-\delta\zeta\left(1-\varpi\right)\phi_{tr}f_{tr}\right]\end{array}}{\left(1-\delta\zeta(1-\phi_{tr})(1-\varpi)\right)^2}\right) \\ -\left(\frac{-\delta^2\zeta^2\phi_{pr}\varpi f_{pr}(1-\varpi)}{\left[(1-\delta\zeta(1-\varpi)(1-\phi_{tr}))\right]^2}\right) \\ +\left(\frac{\begin{array}{c} -\left(1-\phi_{pr}\right)\delta\zeta\varpi\left(a_{pr}-w_{pr}-\delta\zeta\phi_{pr}f_{pr}\right) \\ \left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\delta\zeta\left(1-\varpi\right)\end{array}}{\left[\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta(1-\varpi)(1-\phi_{tr})\right)\right]^2}\right) \end{array}\right] \tag{278}$$

$$\frac{\partial \phi_{tr,0}}{\partial \phi_{pr}} = -\frac{1}{\zeta^{15}}\Gamma'_{f,0} \left[\begin{array}{c} \dfrac{\begin{array}{c} \left[\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right)\right] \\ \left[\begin{array}{c} -\delta\zeta\varpi\left(a_{pr}-w_{pr}\right) \\ -\delta^2\zeta^2\varpi f_{pr}\left(1-2\phi_{pr}\right) \end{array}\right] \\ -\left[\begin{array}{c} \left(1-\phi_{pr}\right)\delta\zeta\varpi\left(a_{pr}-w_{pr}\right)- \\ \delta^2\zeta^2\varpi f_{pr}\left(\phi_{pr}-\phi_{pr}^2\right) \end{array}\right] \\ \left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(\delta\zeta\left(1-\varpi\right)\right) \end{array}}{\left[\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right)\right]^2} \\ -\frac{\delta\zeta\varpi f_{pr}}{\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right)} \end{array} \right] \tag{279}$$

$$\frac{\partial \phi_{tr,0}}{\partial \varpi} = -\frac{1}{\zeta^{15}}\Gamma'_{f,0} \left[\begin{array}{c} \dfrac{\begin{array}{c} \delta\zeta\phi_{tr}f_{tr}\left[1-\delta\zeta\left(1-\phi_{tr}\right)\left(1-\varpi\right)\right]- \\ \left[a_{tr}-w_{tr}-\delta\zeta\left(1-\varpi\right)\phi_{tr}f_{tr}\right]\left[\delta\zeta\left(1-\phi_{tr}\right)\right] \end{array}}{\left[1-\delta\zeta\left(1-\phi_{tr}\right)\left(1-\varpi\right)\right]^2} \\ -\dfrac{\begin{array}{c} \left(\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right)\right)\phi_{pr}\delta\zeta f_{pr}- \\ \phi_{pr}\delta^2\zeta^2\varpi f_{pr}\left(1-\phi_{tr}\right) \end{array}}{\left(\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right)\right)^2} \\ +\dfrac{\begin{array}{c} \left[\begin{array}{c} \left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right) \\ -\varpi\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(\delta\zeta\left(1-\phi_{tr}\right)\right) \end{array}\right] \\ \delta\zeta\left(1-\phi_{pr}\right)\left(a_{pr}-w_{pr}-\delta\zeta\phi_{pr}f_{pr}\right) \end{array}}{\left[\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right)\right]^2} \end{array} \right] \tag{280}$$

Thus, we obtain the following expression:

$$\phi_{tr,new} = \phi_{tr,0} + \frac{\partial \phi_{tr,0}}{\partial\left(a_{tr}-w_{tr}\right)}\left[\begin{array}{c} \left(a_{tr,new}-w_{tr,new}\right) \\ -\left(a_{tr,0}-w_{tr,0}\right) \end{array}\right] \tag{281a}$$

$$+\frac{\partial \phi_{tr,0}}{\partial\left(a_{pr}-w_{pr}\right)}\left[\begin{array}{c} \left(a_{pr,new}-w_{pr,new}\right) \\ -\left(a_{pr,0}-w_{pr,0}\right) \end{array}\right] \tag{281b}$$

$$+\frac{\partial \phi_{tr,0}}{\partial f_{tr}}\left(f_{tr,new}-f_{tr,0}\right) \tag{281c}$$

$$+\frac{\partial \phi_{tr,0}}{\partial f_{pr}}\left(f_{pr,new}-f_{pr,0}\right) \tag{281d}$$

$$+\frac{\partial \phi_{tr,0}}{\partial \phi_{tr}}\left(\phi_{tr,new}-\phi_{tr,0}\right) \tag{281e}$$

$$+\frac{\partial \phi_{tr,0}}{\partial \phi_{pr}}\left(\phi_{pr,new}-\phi_{pr,0}\right) \tag{281f}$$

$$+\frac{\partial \phi_{tr,0}}{\partial \varpi}\left(\varpi_{new}-\varpi_0\right) \tag{281g}$$

By defining

$$V = \frac{1}{\zeta^{15}} \Gamma'_{f,0} \left[\begin{array}{c} \left(\frac{\begin{array}{c} -\delta\zeta f_{tr} \left(1-\varpi\right) \left(1-\delta\zeta \left(1-\phi_{tr}\right) \left(1-\varpi\right)\right) - \\ \delta\zeta \left(1-\varpi\right) \left[a_{tr} - w_{tr} - \delta\zeta \left(1-\varpi\right) \phi_{tr} f_{tr}\right] \end{array}}{\left(1-\delta\zeta\left(1-\phi_{tr}\right)\left(1-\varpi\right)\right)^2} \right) \\ -\left(\frac{-\delta^2\zeta^2\phi_{pr}\varpi f_{pr}(1-\varpi)}{\left[\left(1-\delta\zeta(1-\varpi)(1-\phi_{tr})\right)\right]^2} \right) \\ +\left(\frac{\begin{array}{c} -\left(1-\phi_{pr}\right) \delta\zeta\varpi \left(a_{pr} - w_{pr} - \delta\zeta\phi_{pr} f_{pr}\right) \\ \left(1-\delta\zeta\left(1-\phi_{pr}\right)\right) \delta\zeta \left(1-\varpi\right) \end{array}}{\left[\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta(1-\varpi)(1-\phi_{tr})\right)\right]^2} \right) \end{array} \right]_0 , \quad (282)$$

we obtain:

$$\begin{aligned}
\phi_{tr,new} &= \phi_{tr,0} && (283a) \\
&\quad + \frac{\partial \phi_{tr,0}}{\partial \left(a_{tr} - w_{tr}\right)} \left(\frac{1}{1+V}\right) \left[\begin{array}{c} \left(\begin{array}{c} a_{tr,new} \\ -w_{tr,new} \end{array} \right) \\ -\left(\begin{array}{c} a_{tr,0} \\ -w_{tr,0} \end{array} \right) \end{array} \right] && (283b) \\
&\quad + \frac{\partial \phi_{tr,0}}{\partial \left(a_{pr} - w_{pr}\right)} \left(\frac{1}{1+V}\right) \left[\begin{array}{c} \left(\begin{array}{c} a_{pr,new} \\ -w_{pr,new} \end{array} \right) \\ -\left(\begin{array}{c} a_{pr,0} \\ -w_{pr,0} \end{array} \right) \end{array} \right] && (283c) \\
&\quad + \frac{\partial \phi_{tr,0}}{\partial f_{tr}} \left(\frac{1}{1+V}\right) \left(f_{tr,new} - f_{tr,0}\right) && (283d) \\
&\quad + \frac{\partial \phi_{tr,0}}{\partial f_{pr}} \left(\frac{1}{1+V}\right) \left(f_{pr,new} - f_{pr,0}\right) && (283e) \\
&\quad + \frac{\partial \phi_{tr,0}}{\partial \phi_{pr}} \left(\frac{1}{1+V}\right) \left(\phi_{pr,new} - \phi_{pr,0}\right) && (283f) \\
&\quad + \frac{\partial \phi_{tr,0}}{\partial \varpi} \left(\frac{1}{1+V}\right) \left(\varpi_{new} - \varpi_0\right). && (283g)
\end{aligned}$$

Or by substituting the coefficients:

$$\begin{aligned}\phi_{tr,new} &= \phi_{tr,0} - A_{tr}\left[(a_{tr,new} - w_{tr,new}) - (a_{tr,0} - w_{tr,0})\right] \\ &\quad - B_{tr}\left[(a_{pr,new} - w_{pr,new}) - (a_{pr,0} - w_{pr,0})\right] - C_{tr}\left(f_{tr,new} - f_{tr,0}\right) \\ &\quad + D_{tr}\left(f_{pr,new} - f_{pr,0}\right) + E_{tr}\left(\phi_{tr,new} - \phi_{tr,0}\right) + F_{tr}\left(\varpi_{new} - \varpi_0\right)\end{aligned} \tag{284}$$

where A_{tr} to F_{tr} are all positive constants.

Thus, higher productivity and lower wages lead to a reduction of the firing rate. Higher firing costs in the trapped sector reduce firing (not taking their indirect effect via the wage formation into account which outweighs the direct effect), whereas higher firing costs in the primary sector increase firing in the trapped sector. There is a positive spillover effect from the firing rate in the primary sector to the trapped sector, i.e. if the firing rate in the primary sector is reduced, the same is true for the firing rate in the trapped sector. Furthermore, a higher intersectoral mobility reduces firing in the trapped sector (as the average profitability of trapped workers increases).

Hiring Rate: A worker is hired if $\Pi_t > h_{tr}$. Thus:

$$\eta_{tr} = \Gamma\left(\begin{array}{c} \frac{a_{tr}-w_{tr}-\delta(1-\varpi)\phi_{tr}f_{tr}}{1-\delta(1-\phi_{tr})(1-\varpi)} + h_{tr} + \\ \frac{\delta\varpi\phi_{pr}f_{pr}}{(1-\delta\varpi)} + \left(1-\phi_{pr}\right)\delta\varpi\left(\frac{a_{pr}-w_{pr}+\delta\phi_{pr}f_{pr}}{\left(1-\delta\left(1-\phi_{pr}\right)\right)((1-\delta\varpi))}\right)\end{array}\right) \tag{285}$$

Analogous to the firing rate the hiring rate is re-written as:

$$\eta_{tr} = \Gamma\left(\frac{1}{\zeta^{15}}\left(\begin{array}{c} \frac{a_{tr}-w_{tr}-\delta\zeta(1-\varpi)\phi_{tr}f_{tr}}{1-\delta\zeta(1-\phi_{tr})(1-\varpi)} + h_{tr} + \\ \frac{\delta\zeta\varpi\phi_{pr}f_{pr}}{(1-\delta\zeta\varpi)} + \left(1-\phi_{pr}\right)\delta\zeta\varpi\left(\frac{a_{pr}-w_{pr}+\delta\zeta\phi_{pr}f_{pr}}{\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)((1-\delta\zeta\varpi))}\right)\end{array}\right)\right) \tag{286}$$

To obtain the first order Taylor approximation, we need to calculate the first partial derivatives:

$$\frac{\partial\eta_{tr,0}}{\partial\left(a_{tr} - w_{tr}\right)} = \frac{1}{\zeta^{15}}\Gamma'_{h,0}\left[\frac{1}{1-\zeta\delta\left(1-\phi_{tr}\right)\left(1-\varpi\right)}\right]_0 \tag{287}$$

$$\frac{\partial\eta_{tr,0}}{\partial\left(a_{pr}-w_{pr}\right)}=\frac{1}{\zeta^{15}}\Gamma'_{h,0}\left[\frac{\left(1-\phi_{pr}\right)\delta\zeta\varpi}{\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right)}\right] \tag{288}$$

$$\frac{\partial\eta_{tr,0}}{\partial f_{tr}}=\frac{1}{\zeta^{15}}\Gamma'_{h,0}\left[\frac{-\delta\zeta\phi_{tr}\left(1-\varpi\right)}{1-\zeta\delta\left(1-\phi_{tr}\right)\left(1-\varpi\right)}\right]_0 \tag{289}$$

$$\frac{\partial\eta_{tr,0}}{\partial f_{pr}}=\frac{1}{\zeta^{15}}\Gamma'_{h,0}\left[\begin{array}{c}-\frac{\delta\zeta\varpi\phi_{pr}}{(1-\delta\zeta(1-\varpi)(1-\phi_{tr}))}\\ -\frac{\delta^2\zeta^2\varpi\phi_{pr}\left(1-\phi_{pr}\right)}{\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)(1-\delta\zeta(1-\varpi)(1-\phi_{tr}))}\end{array}\right]_0 \tag{290}$$

$$\frac{\partial\eta_{tr,0}}{\partial h}=\frac{1}{\zeta^{15}}\Gamma'_{h,0} \tag{291}$$

$$\frac{\partial\eta_{tr,0}}{\partial\phi_{tr}}=\frac{1}{\zeta^{15}}\Gamma'_{h,0}\left[\begin{array}{c}\left(\frac{\begin{array}{c}-\delta\zeta f_{tr}\left(1-\varpi\right)\left(1-\delta\zeta\left(1-\phi_{tr}\right)\left(1-\varpi\right)\right)-\\ \delta\zeta\left(1-\varpi\right)\left[a_{tr}-w_{tr}-\delta\zeta\left(1-\varpi\right)\phi_{tr}f_{tr}\right]\end{array}}{(1-\delta\zeta(1-\phi_{tr})(1-\varpi))^2}\right)\\ -\left(\frac{-\delta^2\zeta^2\phi_{pr}\varpi f_{pr}(1-\varpi)}{[(1-\delta\zeta(1-\varpi)(1-\phi_{tr}))]^2}\right)\\ +\left(\frac{\begin{array}{c}-\left(1-\phi_{pr}\right)\delta\zeta\varpi\left(a_{pr}-w_{pr}-\delta\zeta\phi_{pr}f_{pr}\right)\\ \left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\delta\zeta\left(1-\varpi\right)\end{array}}{\left[\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)(1-\delta\zeta(1-\varpi)(1-\phi_{tr}))\right]^2}\right)\end{array}\right] \tag{292}$$

$$\frac{\partial\eta_{tr,0}}{\partial\phi_{pr}}=\frac{1}{\zeta^{15}}\Gamma'_{h,0}\left[\begin{array}{c}\frac{\begin{array}{c}\left[\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(1-\delta\zeta\left(1-\varpi\right)\left(1-\phi_{tr}\right)\right)\right]\\ \left[\begin{array}{c}-\delta\zeta\varpi\left(a_{pr}-w_{pr}\right)\\ -\delta^2\zeta^2\varpi f_{pr}\left(1-2\phi_{pr}\right)\end{array}\right]\\ -\left[\begin{array}{c}\left(1-\phi_{pr}\right)\delta\zeta\varpi\left(a_{pr}-w_{pr}\right)-\\ \delta^2\zeta^2\varpi f_{pr}\left(\phi_{pr}-\phi_{pr}^2\right)\end{array}\right]\\ \left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)\left(\delta\zeta\left(1-\varpi\right)\right)\end{array}}{\left[\left(1-\delta\zeta\left(1-\phi_{pr}\right)\right)(1-\delta\zeta(1-\varpi)(1-\phi_{tr}))\right]^2}\\ -\frac{\delta\zeta\varpi f_{pr}}{(1-\delta\zeta(1-\varpi)(1-\phi_{tr}))}\end{array}\right] \tag{293}$$

$$\frac{\partial \eta_{tr,0}}{\partial \varpi} = \frac{1}{\zeta^{15}} \Gamma'_{h,0} \left[\begin{array}{c} \frac{\begin{array}{c} \delta\zeta\phi_{tr} f_{tr} \left[1 - \delta\zeta \left(1 - \phi_{tr}\right) \left(1 - \varpi\right)\right] - \\ \left[a_{tr} - w_{tr} - \delta\zeta \left(1 - \varpi\right) \phi_{tr} f_{tr}\right] \left[\delta\zeta \left(1 - \phi_{tr}\right)\right] \end{array}}{\left[1 - \delta\zeta(1-\phi_{tr})(1-\varpi)\right]^2} \\ - \frac{\begin{array}{c} \left(\left(1 - \delta\zeta \left(1 - \varpi\right) \left(1 - \phi_{tr}\right)\right)\right) \phi_{pr} \delta\zeta f_{pr} - \\ \phi_{pr} \delta^2 \zeta^2 \varpi f_{pr} \left(1 - \phi_{tr}\right) \end{array}}{\left(\left(1 - \delta\zeta(1-\varpi)(1-\phi_{tr})\right)\right)^2} \\ + \frac{\left[\begin{array}{c} \left(1 - \delta\zeta \left(1 - \phi_{pr}\right)\right) \left(1 - \delta\zeta \left(1 - \varpi\right) \left(1 - \phi_{tr}\right)\right) \\ -\varpi \left(1 - \delta\zeta \left(1 - \phi_{pr}\right)\right) \left(\delta\zeta \left(1 - \phi_{tr}\right)\right) \end{array} \right] \\ \delta\zeta \left(1 - \phi_{pr}\right) \left(a_{pr} - w_{pr} - \delta\zeta\phi_{pr} f_{pr}\right)}{\left[\left(1 - \delta\zeta\left(1 - \phi_{pr}\right)\right)\left(1 - \delta\zeta(1-\varpi)(1-\phi_{tr})\right)\right]^2} \end{array} \right] \tag{294}$$

Thus, the first order Taylor approximation is

$$\begin{aligned} \eta_{tr,new} &= \eta_{tr,0} + \frac{\partial \eta_{tr,0}}{\partial \left(a_{tr} - w_{tr}\right)} \left[\left(a_{tr,new} - w_{tr,new}\right) - \left(a_{tr,0} - w_{tr,0}\right)\right] && \text{(295a)} \\ &+ \frac{\partial \eta_{tr,0}}{\partial \left(a_{pr} - w_{pr}\right)} \left[\left(a_{pr,new} - w_{pr,new}\right) - \left(a_{pr,0} - w_{pr,0}\right)\right] && \text{(295b)} \\ &+ \frac{\partial \eta_{tr,0}}{\partial f_{tr}} \left(f_{tr,new} - f_{tr,0}\right) + \frac{\partial \eta_{tr,0}}{\partial f_{pr}} \left(f_{pr,new} - f_{pr,0}\right) && \text{(295c)} \\ &+ \frac{\partial \eta_{tr,0}}{\partial \phi_{tr}} \left(\phi_{tr,new} - \phi_{tr,0}\right) + \frac{\partial \eta_{tr,0}}{\partial \phi_{pr}} \left(\phi_{pr,new} - \phi_{pr,0}\right) && \text{(295d)} \\ &+ \frac{\partial \eta_{tr,0}}{\partial \varpi} \left(\varpi_{new} - \varpi_0\right) && \text{(295e)} \end{aligned}$$

Or by substituting the coefficients

$$\begin{aligned} \eta_{tr,new} &= \eta_{tr,0} + G_{tr} \left[\left(a_{tr,new} - w_{tr,new}\right) - \left(a_{tr,0} - w_{tr,0}\right)\right] && \text{(296a)} \\ &+ H_{tr} \left[\begin{array}{c} \left(\begin{array}{c} a_{pr,new} \\ -w_{pr,new} \end{array} \right) \\ - \left(\begin{array}{c} a_{pr,0} \\ -w_{pr,0} \end{array} \right) \end{array} \right] - I_{tr} \left(\begin{array}{c} f_{tr,new} \\ -f_{tr,0} \end{array} \right) - J_{tr} \left(\begin{array}{c} f_{pr,new} \\ -f_{pr,0} \end{array} \right) \\ &- K_{tr} \left(\begin{array}{c} h_{tr,new} \\ -h_{tr,0} \end{array} \right) - L_{tr} \left(\begin{array}{c} \phi_{tr,new} \\ -\phi_{tr,0} \end{array} \right) && \text{(296b)} \\ &- M_{tr} \left(\begin{array}{c} \phi_{pr,new} \\ -\phi_{pr,0} \end{array} \right) + N_{tr} \left(\begin{array}{c} \varpi_{new} \\ -\varpi_0 \end{array} \right). && \text{(296c)} \end{aligned}$$

where G_{tr} to N_{tr} are all positive coefficients. The rationale for the signs of the coefficients is the same as for the linearized firing rate in the trapped sector.[193]

[193]For the linearized model a value for the first derivative of the cumulative function has to be chosen (Γ'). In chapter 5 for the firing and hiring rate the same values are used, while we choose ($\Gamma'_f = 6 * 10^{-7}$) and ($\Gamma'_h = 6 * 10^{-6}$), where $_f$ and $_h$ stand for the firing and hiring rate respectively. In the homogenous model, this provides us with a similar labor demand elasticity and thus a similar employment path, but is more in line with the empirical evidence on hiring and firing elasticities (for a summary, see Orszag and Snower, 1999).

7 Evaluating the Effectiveness of Employment Subsidies

7.1 Introduction

This chapter[194] aims to provide a groundwork for comparing the effectiveness of alternative employment subsidy policies. In doing so, we attempt to make our analysis maximally useful to the decisions that policy makers commonly face in practice.

We focus on employment subsidies because these policies are often meant to reduce both unemployment and earnings inequality together. The quest for such measures has been a prime objective of employment policy throughout the OECD and continues to be central to the policy debate in the large continental European countries.[195]

To make our analysis expressly relevant to policy making, we do not follow the mainstream practice of deriving policies as first-best responses to market failures; rather we begin with a model that covers a variety of common labor market imperfections - insider wage bargaining, hiring and firing costs, and imperfections related to the tax and transfer system - and examine the second-best employment policy response, taking these imperfections as given. We assume, as policy makers often do, that the institutions underlying these imperfections can be changed only gradually and with considerable delay; and thus we argue that it is useful to examine the relative effectiveness of different employment policies while these institutions are in place. Furthermore, in accord with policy makers' actual concerns, we measure policy effectiveness not just in terms of employment and welfare, but also give explicit consideration to earnings inequality and government budgetary outlays.

Due to the labor market imperfections above, the resulting unemployment can be inefficient. Our analysis is appropriate to policy design in high-unemployment countries, such as Germany, where policy makers have every reason to believe that unemployment is in fact inefficiently high. Then, in principle, employment policies may make some people better off without making others worse off.

It is well known that identifying such Pareto welfare-improving policies is

[194] For a different version of this chapter see "Evaluating the Effectiveness of Employment Subsidies," with Alessio Brown and Dennis Snower, Kiel Working Paper, No. 1302, November 2006.

[195] For a detailed discussion of currently applied employment subsidy programs in Germany and recent reform proposals see Boss (2006).

insuperably difficult in practice. Thus our analysis focuses on policies that are "approximately Pareto welfare efficient" - or simply *approximately welfare efficient*, for short - in the following sense:

1. they improve aggregate employment and welfare (defined in terms of the utility functions of the households),
2. they do not increase earnings inequality (measured in terms of the Gini coefficient), and
3. they are self-financing (i.e. they do not require an additional government budgetary allocation).

Clearly, approximate welfare efficiency is not equivalent to Pareto welfare efficiency, because an employment policy can obviously satisfy the three conditions above and still generate uncompensated losers. Nevertheless, we argue that approximate welfare efficiency is a useful concept for policy making, since policies that are approximately welfare efficient are not only desirable for Benthamite reasons (the greatest happiness of the greatest number of people), but are unlikely to be blocked through the political process (since the fear of rising earnings inequality is the most common reason for blocking efficiency-improving employment reforms).[196]

The design of employment policies in most OECD countries indeed reflects governments' need to address both equity and efficiency objectives. The inefficiency of passive unemployment policies - such as the payment of tax-financed unemployment benefits to those who are jobless - is generally due to policy makers' attempt to satisfy equity objectives. Both the unemployment benefits and the taxes that finance them generate externalities: the recipients get an uncompensated benefit, while the tax payers have an uncompensated cost. Thus the work-leisure choice is distorted. The widespread move from passive to active labor market policies is usually motivated by the need to reduce such inefficiencies. Some active labor market policies however appear to have improved employment incentives at the expense of income equality.[197] Against this backdrop, it appears useful to identify policies that increase employment and welfare without raising income inequality.

This chapter addresses two important questions: (i) How should employment policies be targeted? (ii) What should the magnitude of the policy intervention be? There is much disagreement on these issues among policy makers.

[196] See, for example, Orszag and Snower (1998), Saint Paul (1995, 1996 and 1998).
[197] See, for example, Grogger and Karoly (2005).

In practice, there are two broad policy approaches to targeting: The first favors *targeting workers with low incomes and low abilities*; and the second focuses on *targeting the unemployed*. Within each of these approaches, there is a plethora of more detailed choices to be made.[198] Specifically, this chapter compares the effectiveness of the following employment subsidy policies: (i) *wage* subsidies targeted at *workers with low abilities*, (ii) *hiring* vouchers targeted at *long-term unemployed workers,* (iii) *hiring* vouchers targeted at *workers with low abilities*, and (iv) *hiring* vouchers targeted at *long-term unemployed workers with low abilities*.

We address the issue of targeting by examining how much additional employment and social welfare each employment subsidy policy creates. To analyze the desirable magnitude of the policy intervention, we make use of the concept of approximate welfare efficiency. Specifically, we examine how large each particular employment subsidy can become before it ceases to be approximately welfare efficient (AWE). In our analysis, the policies under consideration exhibit "diminishing returns," in the sense that equal incremental increases in each employment subsidy leads to progressively smaller incremental increases in employment and social welfare and a progressively larger government budgetary outlay. We show that, for each employment subsidy, once a critical level is exceeded, it ceases to be self-financing. Recalling that our notion of approximate welfare efficiency involves the satisfaction of three constraints - an employment and welfare constraint, an earnings inequality constraint, and a self-financing constraint - we find, in our calibration exercises, that as each subsidy is increased, the self-financing constraint is reached first. Thus the self-financing constraint determines the magnitude of each policy intervention that is compatible with approximate welfare efficiency.

On this basis, we then compare the effectiveness of alternative employment subsidy policies. Our notion of policy effectiveness is related to a policy's ability to raise employment and welfare, while remaining AWE. The more an

[198] For example, if workers with low incomes are the focus, how narrowly should they be targeted? (Should employment-promoting policies be directed mainly, say, at the lowest decile or the lowest quintile?) How should the magnitude of the policy intervention depend on incomes? (For instance, should the employment subsidy or tax rebate rise as income falls, or should the profile be hump-shaped, as for the U.S. Earned Income Tax Credit?) If unemployed workers are the target group, then how narrowly should the policy be targeted at the long-term unemployed and how should the magnitude of the employment-promoting intervention depend on the duration of unemployment? Alternatively, should the policy be targeted at young or old unemployed people, and if so, how?

Beyond that, the two approaches could be combined. The policy could, for example, be targeted at low-skilled, unemployed workers. If so, what should be the relative importance of skills versus unemployment duration in the policy targeting scheme?

approximately welfare efficient policy raises employment and welfare, the more "effective" we denote the policy to be.

Our analysis tackles these issues by presenting a model that is rich enough to capture the various groups of workers relevant to these alternative targeting approaches, while at the same time being simple enough to generate straightforward policy guidelines. We calibrate the model for the German labor market, which has characterized by high aggregate and long-term unemployment over the past three decades, and we then derive the corresponding policy implications.

We show that, for the calibrated model, a hiring voucher targeted at the long-term unemployed is particularly effective in raising employment and welfare, without reducing income inequality or requiring an additional government budget outlay. (In fact, as noted, the employment- and welfare-maximizing AWE subsidy reduces earnings inequality.) Furthermore, we find that hiring vouchers targeted at the duration of unemployment are more effective in raising employment and welfare than those targeted at unskilled (low-ability) workers. Moreover, while low wage subsidies (LWS) can also reduce income inequality, they are a relatively expensive and ineffective instrument for reducing unemployment. These are striking results.

We also investigate the employment and equity effects of implementing employment subsidies in excess of the magnitudes that are self-financing. Specifically, we examine how much employment could be created by each of the policy measures under consideration if the government's net budgetary allocation for this measures were increased by a specified amount. Here, too, we find that hiring vouchers targeted at the long-term unemployed have relatively strong employment creating effects, without inequality implications. Subsidies targeted at low-ability workers turn out to be less effective.

The chapter is organized as follows. Section 2 provides some background to our analysis. Section 3 presents our theoretical model of the labor market. Section 4 calibrates this model for Germany, shows the driving effects to make a policy effective and derives the policy implications. Finally, Section 5 concludes.

7.2 Background

7.2.1 The Two Great Divides

Our analysis deals with the "two great divides" that separate the haves from the have-nots in the labor market: (i) the divide between employment and unemployment and (ii) the divide between high-wage and low-wage jobs. The first divide is central to the employment policy debate in Europe, while the second receives relatively more attention in the United States.

Both divides may be inefficient and inequitable. Unemployment and working poverty are obvious sources of income inequality. These problems may also reflect inequality of opportunity if the incentives to work and search for jobs are unequally distributed among the working population. Furthermore, unemployment and working poverty are inefficient when incentives for work, job search, and human capital acquisition have been distorted. For these reasons these problems become legitimate objects of government policies. A wide variety of employment policy instruments have been used for this objective: income taxes and income tax credits, wage subsidies, hiring vouchers, in-kind benefits, and so on. For the purposes of our chapter, we are concerned only with the effect of these policy instruments on incentives in the labor market; different policies that create the same incentives will be indistinguishable in our model. On this account, we will denote all these instruments as "employment subsidies," in the sense that they promote employment by altering the incentives of labor market participants. The central issues of this chapter are how to target these subsidies and how large the subsidies should be.

The two divides are not completely separate phenomena. For example, long-term unemployment can lead to skill attrition, lower productivity, and thereby to low-wage jobs. Low-wage jobs are frequently associated with relatively high labor turnover and thus the low-wage job holders often become relatively prone to unemployment. Thus both of the above policy approaches - those targeted at low incomes/skills and those targeted at the unemployed - will affect both unemployment and working poverty. On this account, we will analyze both problems within the same analytical framework.

Some commentators[199] have noted that, with regard to individual welfare, there is often little to distinguish the unemployed in Europe from the working poor in the US. Both groups tend to have relatively low living standards. With regard to the economy's productive potential, however, there may be

[199] See, for example, Krugman (1994) and Freeman (1995).

significant differences. The working poor produce goods and services, whereas the unemployed do not. Moreover, the unemployed impose costs on the rest of society - since their unemployment benefits and related welfare entitlements are paid largely by employers and employees, as are some of the crime and health costs generated by the unemployed - whereas the working poor tend to do so only to a lesser degree. Beyond that, the unemployed suffer depreciation of their human capital, whereas the working poor may gain human capital, possibly in terms of work habits and contacts to employment opportunities.[200] These phenomena are captured by our model.

In our model, differences in productivity among workers are due to both differences in ability and differences in unemployment duration (via skill attrition). This distinction is important, since ability and unemployment duration differ in their amenability to policy influence. In practice, unemployment duration is readily affected through the standard employment policy instruments, whereas ability can be affected primarily though education and training policy and this influence takes a comparatively long-time to manifest itself. Since our focus is on employment policy, we let the unemployment duration-dependent productivity differences be endogenous (influenceable by the policy), whereas the ability-dependent productivity differences are defined as exogenous (not influenceable by the policy).[201]

7.2.2 Relation to the Literature

There is a large theoretical and empirical literature on the impact and optimal design of employment subsidies, originated with the work by Pigou (1933) and Kaldor (1936).[202]

Even today, many theoretical analyses are still static and thus suffer from the serious drawback that they capture only short-run impact effects of employment policy.[203] There are however good theoretical and empirical rea-

[200] Naturally, these differences must not be overplayed. The productivity of the working poor is often low and thus their output of goods and services, relative to the voluntary and informal work of the unemployed, is accordingly limited. Furthermore, as governments throughout the OECD have begun to shift from passive to active labor market measures, so the costs that the working poor impose on the rest of society have risen and the corresponding costs of the unemployed have fallen.

[201] Our analysis can be extended to education and training policy; see, for example, Oskamp and Snower (2006).

[202] For a survey of the empirical literature, see for example Katz (1998). For US evidence, see Woodbury and Spiegelman (1987) and O'Leary et al. (2006). For international evidence, see for example N.E.R.A. (1995), and for British evidence, see Bell et al. (1999). As follows, we will focus on theoretical papers and the calibration thereof.

[203] See, e.g., Layard et al. (1991), pp. 490-492, and Snower (1994).

sons to believe that longer-run effects are important, often more important than the short-run effects.[204] (There are various significant dynamic interconnections. For example, hiring in response to employment policy takes time and may have persistent effects since incumbent employees' probability of being retained generally exceeds the unemployed people's probability of being hired.) We explicitly capture the dynamic effects of subsidies by specifying the transition rates between employment and unemployment as a function of the employment incentives of the firm.

We contribute to the existing literature by considering, as noted, skills depending unemployment duration as well as on different levels of ability. This detailed grid allows us to analyze and contrast the effects of employment subsidies targeted at different skill classes under the criteria approximative welfare efficiency - explicitly taking the complete budgetary effects into account.[205]

This is in stark contrast to the existing literature which only considers a small subset of possible targets for employment subsidies. A large part examines the rationale and economic effects of subsidies for the low skilled (e.g. Phelps, 1994, 1997a, 1997b, Drèze and Snessens, 1997, and Oskamp and Snower, 2006)[206], while less attention has been given to subsidies to long-term unemployed workers (Hui and Trivedi, 1986, Snower, 1994, Vereshchagina, 2002).

We now proceed to present how these heterogeneities are modelled in our analytical framework.

7.3 The Model

We construct a Markov model of the labor market in which the dynamics of employment and unemployment is determined by transition probabilities among various labor market states. We derive these transition probabilities from optimization principles.

As noted, our model is meant to be both rich enough to capture unemployment-duration dependent and ability-dependent skills, but it also aims to be simple

[204] Orszag and Snower (2000) have shown that the dynamic, long-run effects of employment subsidies, once the associated lagged adjustment processes have worked themselves out, differ from what may be expected in the short run.

[205] Orszag and Snower (2003a and 2003b) pointed out the fact that the literature disregarded the complete impact of employment subsidies on the government budget constraint by requiring that aggregate payroll taxes finance aggregate employment subsidies and thereby ignoring the reduction of unemployment benefit payments, which result from reduced employment. In this paper we follow their line of reasoning.

[206] Mortensen and Pissarides (2003) analyze low wage and hiring subsidies, but do not take different unemployment durations into account.

enough to generate straightforward, intuitively transparent, policy guidelines. Accordingly, our model involves some judicious compromises between analytical simplicity and the depiction of heterogeneous labor market behaviors.

Specifically, our model contains workers in three ability classes: low-ability, medium-ability and high-ability workers, denoted by $\alpha_a = lo, me, hi$, respectively. These ability classes can be interpreted as the exogenous component of skill differences, specifically, exogenous with respect to the employment policies under consideration in this chapter. Within each ability class, there are workers in five labor market states:

1. the *long-term unemployed* $\left(U^L\right)$, who have been unemployed for more than a year (the period of analysis),
2. the *short-term unemployed* $\left(U^S\right)$, who have been unemployed up to one year,
3. the *primary entrants* $\left(N^{E1}\right)$, who are short-term employed workers (employed up to one year) that were previously short-term unemployed,
4. the *secondary entrants* $\left(N^{E2}\right)$, who are short-term employed workers that were previously long-term unemployed, and
5. the *insiders* $\left(N^I\right)$, who are long-term employed, i.e. employed for more than a year.

We assume that insiders are more productive than primary entrants who, in turn, are more productive than secondary entrants. (The terms "primary" and "secondary" are taken from the literature on dual labor markets[207], where workers in the primary sector are more productive than those in the secondary sector.) Our model describes labor market activity for workers in each ability class as a Markov process involving these five states. The transition probabilities among these states are derived from microeconomic foundations. As noted, we treat the ability classes as exogenous with respect to employment policy, and thus we assume that there are no transitions among these ability classes.[208]

In sum, workers in our model occupy three ability classes ($\alpha_a = hi, me, lo$, i.e. low, medium, and high ability) and three duration-dependent classes,

[207] See e.g. Dickens and Lang (1988).

[208] With respect to training policy, these ability classes would become endogenous, as in Oskamp and Snower (2006).

if employed ($d_n = I, E1, E2$, i.e. insiders, primary entrants and secondary entrants), or two duration-dependent classes, if unemployed ($d_u = S,\ L$, i.e. short-term and long-term unemployed). We assume constant returns to labor. Let $a_{\alpha_a}^{d_n}$ be the labor productivity of an employee in duration class d_n and ability class α_a.[209] The firm faces a random cost $\xi_{\alpha_a,t}$, which is iid across workers and time within the ability class α_a. This cost may be interpreted as, say, an operating cost or a negative productivity shock. Its mean is normalized to zero and its cumulative distribution $\Gamma_{\alpha_a}\left(\xi_{\alpha_a}\right)$ is time-invariant.

Agents in our model pursue the following sequence of decisions. First the government sets the income tax rate to ensure that its tax receipts are equal to its net budgetary allocation on employment subsidies. Second, wages are determined through bargaining. Third, the random operating costs are revealed and then employment decisions are made.

7.3.1 The Government Budget Constraint

For simplicity, our model considers only four instruments of government policy: (i) a payroll tax, with a tax rate τ , (ii) an unemployment benefit $b_{\alpha_a,t}$, (iii) an employment subsidy, specifically a hiring voucher $\sigma_{\alpha_a,t}^{d_u}$ targeted at workers of duration-dependent groups and ability-dependent groups or a wage subsidy $\sigma_{\alpha_a,t}$ for employees of certain abilities α_a, and (iv) the net allocation of government expenditures G_t to employment subsidies.

The government budget is given by

$$G_t+\sum_{\alpha_a} n_{\alpha_a,t} l_{\alpha_a} w_{\alpha_a,t}\tau = \sum_{\alpha_a}\sum_{d_u} u_{\alpha_a,t}^{d_u} l_{\alpha_a} b_{\alpha_a,t}+\sum_{\alpha_a}\sum_{d_u}\sigma_{\alpha_a,t}^{d_u} u_{\alpha_a,t}^{d_u} l_{\alpha_a}\eta_{\alpha_a,t}^{d_u}+\sum_{\alpha_a}\sigma_{\alpha_a,t} l_{\alpha_a} n_{\alpha_a,t} \tag{297}$$

For simplicity, our model has only one tax: a proportional payroll tax paid by employed workers. This tax rate τ balances the government budget in absence of subsidies (i.e., $\sigma_{\alpha_a,t} = \sigma_{\alpha_a,t}^{d_u} = 0$ and $G_t = 0$), thereby finances payments of the unemployment benefit $b_{\alpha_a,t}$ to all short-term and long-term unemployed workers.

We take the net allocation of government expenditures G_t to employment subsidies as exogenously given. The *gross* allocation of government expenditures is equal to the total amount that the government spends on employment

[209] We follow the notational convention that only those variables have time subscripts that actually vary through time in our model.

subsidies. If these subsidies create employment, then they generate subsidy-induced revenue for the government, by leading to a fall in the number of people requiring unemployment benefits and an increase in the number of people paying taxes. The *net* allocation of government expenditures G_t is equal to the gross allocation minus the subsidy-induced revenue.[210] When $G_t = 0$, the government budget on employment subsidies is balanced, employment subsidies are self-financing.

7.3.2 Wage Determination

For simplicity, let the wage w_{α_a} for each ability class α_a be the outcome of a Nash bargain between the median insider of that ability class and her firm. The median insider faces no risk of dismissal at the negotiated wage.[211] The wage is renegotiated in each period t. Each worker has the following utility function

$$Ut_t(c) = c_t^{\xi}, \tag{298}$$

which depends positively on consumption c_t.[212] Under bargaining agreement, the insider receives the wage $w_{\alpha_a,t}(1-\tau)$, where τ is the payroll tax rate, and the firm receives the expected profit $\left(a_{\alpha_a}^I - w_{\alpha_a,t}\right)$ in each period t. Thus the expected present value of the insider's utility $V_{\alpha_a,t}^I$ under bargaining agreement is

$$V_{\alpha_a,t}^I = \left(w_{\alpha_a,t}(1-\tau)\right)^{\xi} + \delta\left(\left(1-\phi_{\alpha_a,t+1}\right)V_{\alpha_a,t+1}^I + \phi_{\alpha_a,t+1}V_{\alpha_a,t+1}^S\right) \tag{299}$$

[210] Along these lines, the net allocation of government expenditures to employment subsidies can be calculated as $G_t = \sum_\alpha \sum_{d_u} \sigma_{\alpha,t}^{d_u} u_{\alpha,t}^{d_u} l_\alpha \eta_{\alpha,t}^{d_u} + \sum_\alpha \sigma_{\alpha,t} l_\alpha n_{\alpha,t} - \left(\Delta_t \sum_\alpha n_{\alpha,t} l_\alpha w_{\alpha,t}\tau_t - \Delta_t \sum_\alpha \sum_{d_u} u_{\alpha,t}^{d_u} l_\alpha b_{\alpha,t}\right)$, where Δ_t denotes the change in the respective revenue/expenditure.

[211] These assumptions are made merely for analytical convenience; various other assumptions would lead to similar results. For example, we could assume that the wage in each sector is determined through bargaining between an insider and her firm in that sector, and that the trapped workers have a higher replacement ratio than the primary workers. The net replacement rates (unweighted average across six family types) of workers with 67, 100, and 150 percent of average productivity are 78.25, 68.25, and 64.67 percent, respectively (see Technical Appendix and OECD, 2006).

Alternatively, the wage could be determined through bargaining between the firm and a sector-specific or economy-wide union that represents the senior workers (i.e. workers who do not face a risk of dismissal at the bargained wage). Finally, the wage could be the outcome of a bargain between the firm and the marginal worker, or between the firm an a union representing all employees. In this last case, the insiders' objective in the bargain will depend on their retention rate.

[212] In our model, for simplicity, workers consume all their income.

where $\phi_{\alpha_a,t+1}$ is the firing rate and $V^S_{\alpha_a,t+1}$ the expected present value of a short-term unemployed workers' returns. The expected present value of firm's returns under bargaining agreement are

$$\Pi^I_{\alpha_a,t} = \left(a^I_{\alpha_a} - w_{\alpha_a,t} + \sigma_{\alpha_a}\right) + \delta\left(\left(1-\phi_{\alpha_a,t+1}\right)\Pi^I_{\alpha_a,t+1} - \phi_{\alpha_a,t+1} f_{\alpha_a,t+1}\right) \quad (300)$$

where $f_{\alpha_a,t+1}$ are firing costs.

Under disagreement, the insider's fallback income is $b_{\alpha_a,t}$, assumed for simplicity to be equal to the unemployment benefit. The firm's fallback profit is $-f_{\alpha_a,t}$, i.e. during disagreement the insider imposes the maximal cost on the firm (e.g. through strike, work-to-rule, sabotage) short of inducing dismissal. Assuming that disagreement in the current period does not affect future returns, the present values of utility under disagreement for the insider are

$$V'^I_{\alpha_a,t} = \left(b_{\alpha_a,t}\right)^\xi + \delta\left(\left(1-\phi_{\alpha_a,t+1}\right)V^I_{\alpha_a,t+1} + \phi_{\alpha_a,t+1}V^S_{\alpha_a,t+1}\right) \quad (301)$$

and for the firm are

$$\Pi'^I_{\alpha_a,t} = -f_{\alpha_a,t} + \delta\left(\left(1-\phi_{\alpha_a,t+1}\right)\Pi^I_{\alpha_a,t+1} - \phi_{\alpha_a,t+1} f_{\alpha_a,t+1}\right) \quad (302)$$

Thus, the insider's bargaining surplus is

$$\begin{aligned} V^I_{\alpha_a,t} - V'^I_{\alpha_a,t} &= \left(w_{\alpha_a,t}(1-\tau)\right)^\xi + \delta\left(\left(1-\phi_{\alpha_a,t+1}\right)V^I_{\alpha_a,t+1} + \phi_{\alpha_a,t+1}V^S_{\alpha_a,t+1}\right) \\ &\quad - \left(b_{\alpha_a,t}\right)^\xi - \delta\left(\left(1-\phi_{\alpha_a,t+1}\right)V^I_{\alpha_a,t+1} + \phi_{\alpha_a,t+1}V^S_{\alpha_a,t+1}\right) \\ &= \left(w_{\alpha_a,t}(1-\tau)\right)^\xi - \left(b_{\alpha_a,t}\right)^\xi \qquad (303) \end{aligned}$$

and the firm's surplus is

$$\begin{aligned} \Pi^I_{\alpha_a,t} - \Pi'^I_{\alpha_a,t} &= \left(a^I_{\alpha_a} - w_{\alpha_a,t} + \sigma_{\alpha_a}\right) + \delta\begin{pmatrix} \left(1-\phi_{\alpha_a,t+1}\right)\Pi^I_{\alpha_a,t+1} \\ -\phi_{\alpha_a,t+1} f_{\alpha_a,t+1} \end{pmatrix} - \\ &\quad \left(-f_{\alpha_a,t} + \delta\left(\left(1-\phi_{\alpha_a,t+1}\right)\Pi^I_{\alpha_a,t+1} - \phi_{\alpha_a,t+1} f_{\alpha_a,t+1}\right)\right) \\ &= a^I_{\alpha_a} - w_{\alpha_a,t} + \sigma_{\alpha_a} + f_{\alpha_a,t} \qquad (304) \end{aligned}$$

The negotiated wage maximizes the Nash product (Λ):

$$\Lambda = \left(\left(w_{\alpha_a,t}(1-\tau)\right)^\xi - \left(b_{\alpha_a,t}\right)^\xi\right)^\mu \left(a^I_{\alpha_a} - w_{\alpha_a,t} + \sigma_{\alpha_a} + f_{\alpha_a,t}\right)^{1-\mu}, \quad (305)$$

where μ represents the bargaining strength of the insider relative to the firm.

Thus, the following relationship holds:

$$(1-\mu)\left(\left[w_{\alpha_a,t}(1-\tau)\right]^{\xi}-b_{\alpha_a,t}^{\xi}\right) = \mu\xi\left[w_{\alpha_a,t}(1-\tau)\right]^{\xi-1} \left(\begin{array}{c} a_{\alpha_a}^{I}-w_{\alpha_a,t}+ \\ \sigma_{\alpha_a}+f_{\alpha_a,t} \end{array}\right)(1-\tau). \quad (306)$$

In the labor market equilibrium, let firing costs be proportional to the wage, $f_{\alpha_a,t}=\rho w_{\alpha_a,t}$, and the unemployment benefit be proportional to the wage as well, $b_{\alpha_a,t}=rr_{\alpha_a}(1-\tau)w_{\alpha_a,t}$, where rr_{α_a} is the net replacement ratio. Then the negotiated wage is

$$w_{\alpha_a}=\frac{\mu\xi}{\left[(1-\mu)\left(1-rr_{\alpha_a}^{\xi}\right)+\mu\xi(1-\rho)\right]}\left(a_{\alpha_a}^{I}+\sigma_{\alpha_a}\right) \quad (307)$$

Since the wage is renegotiated in each period, the present value in period t is independent of the present value in period $t+1$.

7.3.3 Transitions among Labor Market States

The transitions among the labor market states are summarized in figure (29).[213] For analytical simplicity, we choose to describe these transitions in terms of a small number of transition variables.

The short-term unemployed $\left(U^S\right)$ are hired with probability η^S and then become primary entrants $\left(N^{E1}\right)$; with probability $\left(1-\eta^S\right)$ they remain unemployed and then join the long-term unemployed $\left(U^L\right)$, thereby losing productivity. The long-term unemployed are hired with probability η^L and then become secondary entrants $\left(N^{E2}\right)$; with probability $\left(1-\eta^L\right)$ they remain long-term unemployed.

At the end of a period, the primary entrants turn into insiders $\left(N^I\right)$, and thereby gain productivity. As insiders, they lose their jobs with probability ϕ and then become primary entrants; with probability $(1-\phi)$ they are retrained.[214] The same holds for the secondary entrants: they, too, turn into insiders, who have a ϕ chance of losing their jobs and a $(1-\phi)$ chance of retaining them.[215]

[213] To simplify notation, we suppress the subscripts refering to ability (α) and time (t) in figure (29), e.g. short-term unemployment ($d_u=S$) is written as U^S rather than $U^S_{\alpha,t}$.

[214] Entrants turn into insiders at the end of a period. In case they are fired at the beginning of the next period these entrants have been insiders just for an instant. That is the reason why for expositional convenience in figure 1 we let entrants become insiders only if retained.

[215] Since all employed workers have the same productivity once they have been employed

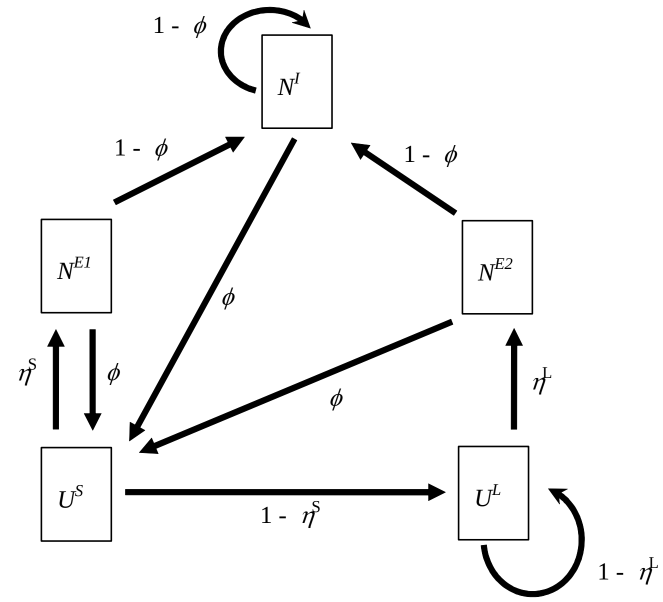


Figure 29: Transitions among labor market states

In short, human capital depreciates with the duration of unemployment and appreciates with the duration of employment.

Thus the labor market system for each ability group a in period t may be described as follows:

$$S_{\alpha_a,t} = T_{\alpha_a,t} S_{\alpha_a,t-1} \tag{308}$$

where S_t is a vector of the labor market states:

$$S_{\alpha_a,t} = \left(N^I_{\alpha_a,t}, N^{E1}_{\alpha_a,t}, N^{E2}_{\alpha_a,t}, U^S_{\alpha_a,t}, U^L_{\alpha_a,t}\right)' \tag{309}$$

and $T_{\alpha_a,t}$ is a Markov matrix of transition probabilities:

$$T_{\alpha_a,t} = \begin{matrix} (1-\phi_{\alpha_a,t}) & (1-\phi_{\alpha_a,t}) & (1-\phi_{\alpha_a,t}) & 0 & 0 \\ 0 & 0 & 0 & \eta^S_{\alpha_a,t} & 0 \\ 0 & 0 & 0 & 0 & \eta^L_{\alpha_a,t} \\ \phi_{\alpha_a,t} & \phi_{\alpha_a,t} & \phi_{\alpha_a,t} & 0 & 0 \\ 0 & 0 & 0 & (1-\eta^S_{\alpha_a,t}) & (1-\eta^L_{\alpha_a,t}) \end{matrix} \tag{310}$$

for a period (and thus, if they are retained, will become insiders in the next period), they all face the same firing probability ϕ.

We now proceed to derive the transition probabilities from microeconomic foundations.

7.3.4 Hiring and Firing

First consider the *firing rate* ϕ_{α_a} *for insiders.* An insider is associated with the wage w_{α_a} and the firing cost f_{α_a}. Let the time discount factor be δ. Recalling that the insider's productivity is $a^I_{\alpha_a}$ and a wage subsidy for a worker with ability α_a is σ_{α_a}, the expected present value of profit generated by an insider, after the random cost $\xi_{\alpha_a,t}$ at time t is observed, is[216]

$$\begin{aligned}\Pi^I_{\alpha_a,t} &= \left(a^I_{\alpha_a} - w_{\alpha_a} - \xi_{\alpha_a,t} + \sigma_{\alpha_a}\right) + \\ &\sum_{i=t+1}^{\infty} \delta^i \left[\begin{array}{c} \left(1-\phi_{\alpha_a}\right)^i \left(a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a}\right) \\ -\phi_{\alpha_a} f_{\alpha_a} (1-\phi_{\alpha_a})^{i-1} \end{array}\right], \end{aligned} \tag{311}$$

so that

$$\Pi^I_{\alpha_a,t} = \frac{a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a} - \delta\phi_{\alpha_a} f_{\alpha_a}}{1-\delta\left(1-\phi_{\alpha_a}\right)} - \xi_{\alpha_a,t} \tag{312}$$

The expected incentive to retain the insider $\left(\nu^I_{\alpha_a}\right)$ is defined as the difference between the expected profit from retaining the insider $\left(\frac{a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a} - \delta\phi_{\alpha_a} f_{\alpha_a}}{1-\delta\left(1-\phi_{\alpha_a}\right)}\right)$ and the expected profit from firing him $(-f_{\alpha_a})$, i.e. this *insider retention incentive* is

$$\nu^I_{\alpha_a} = \frac{a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a} - \delta\phi_{\alpha_a} f_{\alpha_a}}{1-\delta\left(1-\phi_{\alpha_a}\right)} + f_{\alpha_a} \tag{313}$$

An insider is fired in period t when the realized value of the random cost $\xi_{\alpha_a,t}$ is greater than the insider employment incentive:[217] $\xi_{\alpha_a,t} > \nu^I_{\alpha_a}$. Since the cumulative distribution of the operating cost is $\Gamma_{\alpha_a}\left(\xi_{\alpha_a,t}\right)$, the insider's firing rate is

$$\phi_{\alpha_a} = 1 - \Gamma_{\alpha_a}\left(\nu^I_{\alpha_a}\right) \tag{314}$$

Next consider the *hiring rate* $\eta^S_{\alpha_a}$ *for short-term unemployed workers.* The

[216] In the first period, profit is $\left(a^I_{\alpha} - w_{\alpha} - \varepsilon_{\alpha,t} + \sigma_{\alpha}\right)$; in the second period, the insider is retained with probability $(1-\phi_{\alpha})$ and then generates an expected profit of $a^I_{\alpha} - w_{\alpha} + \sigma_{\alpha}$, and the insider is fired with a probability of ϕ_{α} and then generates a firing cost of f_{α}; and so on.

[217] Equivalently, the insider is fired when the profit from retaining the insider is less than the firing cost: $\frac{a^I_{\alpha} - w_{\alpha} + \sigma_{\alpha} - \delta\phi_{\alpha} f_{\alpha}}{1-\delta(1-\phi_{\alpha})} - \varepsilon_{\alpha,t} < f_{\alpha}$.

expected present value of profit generated by a *primary entrant* (a worker who has been hired after being short-term unemployed), after the random cost $\xi_{\alpha_a,t}$ at time t is observed, is

$$\begin{aligned}\Pi^{E1}_{\alpha_a,t} &= \left(a^{E1}_{\alpha_a} - w_{\alpha_a} - \xi_{\alpha_a,t} - h_{\alpha_a} + \sigma_{\alpha_a} + \sigma^S_{\alpha_a}\right) \\ &\quad + \sum_{i=t+1}^{\infty} \delta^i \left(\begin{array}{c} \left(1-\phi_{\alpha_a}\right)^i \left(a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a}\right) \\ -\phi_{\alpha_a} f_{\alpha_a} (1-\phi_{\alpha_a})^{i-1} \end{array} \right)\end{aligned} \tag{315}$$

so that

$$\begin{aligned}\Pi^{E1}_{\alpha_a,t} &= a^{E1}_{\alpha_a} - w_{\alpha_a} - \xi_{\alpha_a,t} - h_{\alpha_a} + \sigma_{\alpha_a} + \sigma^S_{\alpha_a} + \\ &\quad \frac{\delta\left(1-\phi_{\alpha_a}\right)\left(a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a}\right) - \phi_{\alpha_a} f_{\alpha_a} \delta}{1-\delta\left(1-\phi_{\alpha_a}\right)},\end{aligned} \tag{316}$$

where $\sigma^S_{\alpha_a}$ is a hiring voucher for a short-term unemployed worker with ability α_a.[218]

The expected incentive to hire a short-term unemployed worker $\left(\nu^S_{\alpha_a}\right)$ is defined as the difference between the expected profit from employing the primary entrant and the expected profit from not doing so (i.e. zero). Thus the *short-term unemployed hiring incentive* is

$$\nu^S_{\alpha_a} = a^{E1}_{\alpha_a} - w_{\alpha_a} - h_{\alpha_a} + \sigma_{\alpha_a} + \sigma^S_{\alpha_a} + \frac{\delta\left(1-\phi_{\alpha_a}\right)\left(a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a}\right) - \phi_{\alpha_a} f_{\alpha_a} \delta}{1-\delta\left(1-\phi_{\alpha_a}\right)} \tag{317}$$

A primary entrant is hired in period t when the realized value of the random cost $\xi_{\alpha_a,t}$ is less than the primary entrant hiring incentive:[219] $\xi_{\alpha_a,t} < \nu^S_{\alpha_a}$. Thus the hiring rate for short-term unemployed is

$$\eta^S_{\alpha_a} = \Gamma_{\alpha_a}\left(\nu^S_{\alpha_a}\right) \tag{318}$$

[218] Clearly, a wage subsidy raises current and expected future expected profits of all employees of the respective ability and thus, raises the hiring rates as well as lowers the firing rate. A hiring voucher, however, affects only the current period profit of the respectively subsidised entrant and thereby her respective hiring rate. For the influence of the subsidies in the linearized model see Appendix 7.6.1.

[219] Equivalently, the primary entrant is hired when the profit from employing this worker is greater than than the hiring cost: $a^{E1}_{\alpha} - w_{\alpha} - \varepsilon_{\alpha,t} + \sigma_{\alpha} + \sigma^S_{\alpha} + \frac{\delta(1-\phi_{\alpha})\left(a^I_{\alpha} - w_{\alpha} + \sigma_{\alpha}\right) - \delta\phi_{\alpha} f_{\alpha}}{1-\delta(1-\phi_{\alpha})} > h_{\alpha}$.

Finally, consider the *hiring rate* $\eta^L_{\alpha_a}$ *for the long-term unemployed.* The expected present value of profit generated by a *secondary entrant* (a worker who has been hired after being long-term unemployed), after the random cost $\xi_{\alpha_a,t}$ at time t is observed, is

$$\begin{aligned}\Pi^{E2}_{\alpha_a,t} \;=\;& a^{E2}_{\alpha_a} - w_{\alpha_a} - \xi_{\alpha_a,t} - h_{\alpha_a} + \sigma_{\alpha_a} + \sigma^L_{\alpha_a} + \\ & \frac{\delta\left(1-\phi_{\alpha_a}\right)\left(a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a}\right) - \phi_{\alpha_a} f_{\alpha_a}\delta}{1-\delta\left(1-\phi_{\alpha_a}\right)},\end{aligned} \tag{319}$$

where $\sigma^L_{\alpha_a}$ is a hiring voucher for a long-term unemployed worker with ability α_a. The expected incentive to hire a long-term unemployed $\left(\nu^L_{\alpha_a}\right)$ is defined as the difference between the expected profit from employing the secondary entrant and the expected profit from not doing so (i.e. zero). Thus the *long-term unemployed hiring incentive* is

$$\nu^L_{\alpha_a} = a^{E2}_{\alpha_a} - w_{\alpha_a} - h_{\alpha_a} + \sigma_{\alpha_a} + \sigma^L_{\alpha_a} + \frac{\delta\left(1-\phi_{\alpha_a}\right)\left(a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a}\right) - \phi_{\alpha_a} f_{\alpha_a}\delta}{1-\delta\left(1-\phi_{\alpha_a}\right)}. \tag{320}$$

A secondary entrant is hired in period t when the realized value of the random cost $\xi_{\alpha_a,t}$ is less than the secondary entrant hiring incentive:[220] $\xi_{\alpha_a,t} < \nu^L_{\alpha_a}$. Thus the hiring rate for long-term unemployed workers is

$$\eta^L_{\alpha_a} = \Gamma_{\alpha_a}\left(\nu^L_{\alpha_a}\right). \tag{321}$$

7.3.5 Employment and Unemployment

The change in employment in each ability group $(\Delta N_{\alpha_a,t})$ is the difference between the outflow from the unemployment pool $\left(\eta^S_{\alpha_a,t} U^S_{\alpha_a,t-1} + \eta^L_{\alpha_a,t} U^L_{\alpha_a,t-1}\right)$ and the outflow from the employment pool $\left(\phi_{\alpha_a,t} N_{\alpha_a,t-1}\right)$ of that ability group: $\Delta N_{\alpha_a,t} = \eta^S_{\alpha_a,t} U^S_{\alpha_a,t-1} + \eta^L_{\alpha_a,t} U^L_{\alpha_a,t-1} - \phi_{\alpha_a,t} N_{\alpha_a,t-1}$. Assuming a constant labour force L_{α_a} in each ability class and defining the employment rate to be $n_{\alpha_a,t} = N_{\alpha_a,t}/L_{\alpha_a,t}$, we obtain the following *employment dynamics equation*:[221]

$$n_{\alpha_a,t} = \eta^S_{\alpha_a,t} u^S_{\alpha_a,t-1} + \eta^L_{\alpha_a,t} u^L_{\alpha_a,t-1} + \left(1-\phi_{\alpha_a,t}\right) n_{\alpha_a,t-1} \tag{322}$$

[220] Equivalently, the secondary entrant is hired when the profit from employing this worker is greater than than the hiring cost: $a^{E2}_{\alpha} - w_\alpha - \varepsilon_{\alpha,t} + \sigma_\alpha + \sigma^L_\alpha \frac{\delta(1-\phi_\alpha)\left(a^{E2}_\alpha - w_\alpha + \sigma_\alpha\right) - \delta\phi_\alpha f_\alpha}{1-\delta(1-\phi_\alpha)} > h_\alpha$

[221] Note that $\Delta n_{\alpha,t} = \eta^S_{\alpha,t}\left(1-n^S_{\alpha,t-1}\right) + \eta^L_{\alpha,t}\left(1-n^L_{\alpha,t-1}\right) - \phi_{\alpha,t} n_{\alpha,t-1}$.

The long-term unemployed comprise those workers who were either short- or long-term unemployed in the previous period and who have not been hired in the current period. Thus the *long-run unemployment dynamics equation* is

$$u^L_{\alpha_a,t} = \left(1 - \eta^S_{\alpha_a,t}\right) u^S_{\alpha_a,t-1} + \left(1 - \eta^L_{\alpha_a,t}\right) u^L_{\alpha_a,t-1}. \tag{323}$$

The short-term unemployment rate is the difference between the aggregate unemployment rate and the long-term unemployment rate:

$$u^S_{\alpha_a,t} = 1 - n_{\alpha_a,t} - u^L_{\alpha_a,t} \tag{324}$$

7.3.6 The Labor Market Equilibrium

The labor market equilibrium is the solution of the system comprising

- employment and unemployment dynamic equations (322), (323) and (324),
- the government budget constraint, equation (297),
- the firing and hiring rates, equations (314), (318), (321), and
- the wage equation (307).

We now proceed to calibrate the model above for German data and compare the effectiveness of alternatively targeted employment subsidies in terms of AWE. We will proceed as follows: first, the calibration, then an intuitive analysis of the effective policy design and then, the numerical results. In a further step, by relaxing the self-financing constraint, i.e. with a given positive net allocation of government expenditure to the policy, we compare the performance of our different subsidies in a marginal exercise beyond the approximately welfare efficient subsidy.

7.4 Evaluation of Employment Subsidies

7.4.1 Calibration

The period of analysis is one year. The interest rate r is set at 4% per year, which corresponds to the average real interest rate in the OECD over the last four decades, and we set $\delta = \frac{1}{1+r}$. For simplicity, we begin by choosing a utility parameter $\xi = 1$; later we also show results for $\xi = 0.5$.[222]

Firing costs and hiring costs are set proportional to 60 percent ($f_{\alpha_a} = \rho w_{\alpha_a}$ with $\rho = 0.6$) and 10 percent ($h_{\alpha_a} = \mu w_{\alpha_a}$ with $\mu = 0.1$) of the the labor costs respectively (Chen and Funke, 2003). The net replacement rates rr_{α_a} are set to 78.25 percent for low-ability, 68.25 percent for medium-ability, and 64.67 percent for high-ability workers (OECD, 2006).[223] The tax-rate τ that balances the government's budget in the absence of subsidies amounts to 0.069.

Keane and Wolpin (1997) estimated rates of skill depreciation during unemployment: white collar workers lose about 30 percent of their skills after being unemployed for one year, whereas the number is about 10 percent for blue collar workers.[224] In Ljungqvist and Sargent (1998) the rate of depreciation of skills during unemployment is twice the rate of accumulation.[225] In line with these studies we assume an insider productivity advantage is 10 percent and a skill depreciation of 20 percent of the respective productivity due to long-term unemployment.

Figure (8)[226] shows the percentage values for Germany for the three ability classes of the relevant variables of the employment dynamics equations. The percentage share of the labour force l_{α_a} for each ability class for Germany (2002) is taken from OECD (2005a), the respective aggregate unemployment rates for Germany (2002) $u_{\alpha_a,0}$ from OECD (2005b, 2005c). The actual hiring rates for 1996 of each ability and duration group $\eta^S_{\alpha_a,0}$ and $\eta^L_{\alpha_a,0}$ are taken from Wilke's (2005) Kaplan-Meier functions for Germany. According to OECD (2005b, 2005d) the average share of long-term unemployment ($u^L_{\alpha_a,0}/u_{\alpha_a,0}$) is around 50 percent and similar across all ability classes.[227]

The firing rates $\phi_{\alpha_a,0}$ are assigned the values necessary for the model to reproduce the unemployment rates of the respective ability classes[228]. We in-

[222] For the latter, we have decreasing marginal utility of consumption. Thus, in the aggregated welfare function a bigger weight is given to an improvement of low ability workers' income (being closer to Rawlsian welfare).

[223] See Technical Appendix for a description of the calculation of these rates.

[224] See Keane and Wolpin (1997), p. 500.

[225] See Ljungqvist and Sargent (1998), p. 527.

[226] Note that variables with subscript "0" denote the value at the "old" steady state, i.e. before any policy exercise, while variables with subscript "*new*" denote the new steady state after the policy exercise shows its full effects.

[227] See also SVR (2005). In our calibration the share of long-term unemployed is somewhat above 50% for the low-ability and slightly below 50% for the medium- and high-ability, which seems plausible.

[228] The firing rate of 9% for low-ability employees is pretty close to what can be found in the literature (e.g. Brussig and Erlinghagen (2005), Fitzenberger et al. (2003) and Wilke (2005)). The firing rate for high-ability is somewhat lower than in reality since many high-

	low-skilled	medium-skilled	high-skilled	aggregate
l_s	16.6	59.4	24	100
$u_{s,0}$	18	10.2	5.2	10.3
$u^S_{s,0}$	7.7	5.1	2.8	5
$u^L_{s,0}$	10.3	5	2.4	5.3
$u^L_{s,0}/u_{s,0}$	57	49	46	50
$\eta^S_{s,0}$	49	59	55	56.4
$\eta^L_{s,0}$	38	42	51	43.5
$\phi_{s,0}$	9.4	5.7	2.9	5.6

Table 8: Steady state values of the labor share, unemployment, HR and FR for each skill class

terpret these numbers as steady state values.

We linearize the model around the old steady state (see Appendix 7.6.1) and calculate the long-run effects of the policy exercises (new steady state) as permanent deviations from the old steady state. Thus, we have to choose the first derivative of the cumulative density functions in our model ($\Gamma'_{\alpha_a,0}$), which determines the hiring and firing elasticities. For this purpose, we use empirical estimates, as summarized in Orszag and Snower (1999, p. 208). The first derivative of the cumulative function for the hiring rate (${}_\eta\Gamma'_{\alpha_a,0}$)[229] (denoted with subscript $_\eta$) is set in such a way that the hiring elasticity with respect to a hiring voucher is equal to 0.5.[230] Also in line with the aforementioned empirical literature, we set the first derivative of the cumulative function (${}_\phi\Gamma'_{\alpha_a,0}$)[231] for the firing rate (denoted with subscript $_\phi$) in such a way that a one-period reduction of the wage has an elasticity of 0.125.

To double check that we have chosen appropriate hiring and firing elasticities, we compare the endogenous reactions of our model to the empirical labor demand literature. A permanent 10 percent wage cut (ceteris paribus) for low-ability workers generates for example an increase in the employment rate of 8.7 percent in the long-run, which yields an long-term labor demand elasticity of -0.87.[232]

ability workers rotate back into work quickly. This phenomenon cannot be captured by our model since it is calibrated on a yearly basis and workers stay unemployment for at least a year. However, this property does not affect the model dynamics for the performed exercises.

[229] See Appendix 7.6.1.

[230] Reaction of the hiring rate to a hiring voucher for short-term unemployed, which is permanently paid during the first year of the employment spell ($\chi_\alpha = \frac{\partial \eta^S_\alpha}{\eta^S_\alpha} / \frac{\partial \sigma^S_\alpha}{w_\alpha}$). For simplicity, we choose the same ${}_\eta\Gamma'_{0,\alpha}$ for short-term and long-term unemployed in each ability group.

[231] See Appendix 7.6.1.

[232] Note that the endogenous labor demand elasticity in our model varies with the size of the wage movement. The bigger the change in the wage, the smaller is the labor demand

Empirical labor demand elasticities for Germany are generally estimated in a range from -0.3 to -0.9[233]. Sinn et al. (2006, p. 10) point out that these estimation results rather reflect short-term than long-term elasticities, refer to studies where considerable higher estimates have been found for the low wage sector and consider an elasticity of -1 as realistic. Thus, we see ourselves well in line with the empirical labor demand literature for Germany. For a detailed description of the approximations for different abilities' labor costs and wages see Technical Appendix.

Starting from this steady state we will perform policy exercises and compare the resulting new steady states.[234]

7.4.2 Effective Policy Design

We compare the effectiveness of differently targeted employment subsidies under the notion of AWE. As noted, the following criteria have to hold: (i) the subsidies improve aggregate employment and welfare (defined as the sum of the utility of the workforce), (ii) they do not increase earnings inequality (measured in terms of the Gini coefficient[235]), and (iii) they are self-financing (i.e., they do not require a net allocation of government expenditures to the subsidy in the new steady state, $G = 0$.)

It is of course possible that employment subsidies be self-financing. An employment increase (generated by the subsidy) broadens the tax base and thereby, raises the government's revenue, and lower unemployment implies less expenditures on benefit payments. Thus, to be self-financing the subsidies must be financed by the additional tax revenue and the reduction in benefit payments:

$$\begin{aligned} & \sum_{\alpha_a}\sum_{d_u}\sigma_{\alpha_a}^{d_u}u_{\alpha_a}^{d_u}l_{\alpha_a}\eta_{\alpha_a}^{d_u}+\sum_{\alpha_a}\sigma_{\alpha_a}l_{\alpha_a}n_{\alpha_a} \\ = & \left(\Delta\sum_{\alpha_a}n_{\alpha_a}l_{\alpha_a}w_{\alpha_a}\tau-\Delta\sum_{\alpha_a}\sum_{d_u}u_{\alpha_a}^{d_u}l_{\alpha_a}b_{\alpha_a}\right), \end{aligned} \tag{325}$$

where Δ denotes the difference between the value at the new steady state after the policy exercise shows its full effects and the value at the "old" steady state,

elasticity (in absolute terms).

[233] See Riphan et al. (1999).

[234] See Appendix 7.6.1.

[235] Note that the Gini coefficient generated by our model is lower than in reality, as our model does not generate income differentials within ability groups and it does not take non-wage related inequalities into account (e.g., due to the wealth distribution).

i.e. before any policy exercise.

As our numerical results will show, the self-financing constraint is reached before the other constraints associated with approximate welfare efficiency are reached. It turns out that some policies under consideration are not AWE, as they are not self-financing at all.

Thus, before discussing the simulation results, in the following we discriminate different targeting schemes by their potential of being self-financing. Thereby, we identify the main effects that influence the existence and the size of a self-financing area.

Wage Subsidies versus Hiring Vouchers: Let us start with comparing the two most general types of subsidies:

- a wage subsidy σ_{α_a} paid to the firm for each employed worker of a specific ability class[236],
- 1-period hiring voucher $\sigma^{d_u}_{\alpha_a,t}$ paid to the firm for hiring a worker *of a specific target group* (duration and ability).

Our quantitative analysis will show that self-financing areas are more likely to exist and, if they exist, will be larger for hiring vouchers than for wage subsidies. Intuitively, this arises for the following reasons:[237]

Deadweight Effect: First of all, the deadweight (defined as the rate of subsidy payments which are paid to workers who would have been employed in absence of the subsidy) is much larger for wage subsidies than for hiring vouchers. Naturally, the latter also implies some deadweight, vouchers to those unemployed workers who would have been hired also in absence of the subsidy, whereby the deadweight of the former additionally includes subsidies to all employed workers who would have been retained in absence of the subsidy.[238]

[236] Normally, wage-subsidies are targeted at the low-ability workers, i.e. low-wage subsidies, $\alpha = l$.

[237] The following effects are strongly interrelated and reciprocally reinforcing. Thus, we will not try to disentangle them in our numerical excercise.

[238] For example, 82 % of the low-skilled workers in Germany are already employed in absence of a low-wage subsidy, while this groups contains 16.6 % of all workers. Thus, 13.6 % of the workforce would receive a low wage subsidy, although these people would be employed without a subsidy. For hiring vouchers deadweight subsidy payments cover only about 5 % of the workforce.

Wage Effect: The wage-effect plays an important role for wage-subsidies. It is defined as the proportion of the subsidy, which does not increase the firm's surplus, as it is neutralized by wage increases and thus not used for employment creation. Since wages are determined by insiders in our model and wage subsidies are paid for all employed workers of a specific ability, also for insiders, the latter will try to reap part of the subsidy, as they are part of the employers' surplus. Thus, a share of the subsidy goes directly to the workers and the increase in firm's employment incentives for workers of the respective ability class are weakened.

Summary: These two effects make a strong case that hiring vouchers are more likely to be self-financing and thus, AWE than wage subsidies.

Duration versus Ability: As the deadweight effect and the wage effect seem to favor hiring vouchers, we now proceed to analyze whether they should be targeted at specific duration or ability groups. Besides the deadweight effect, the existence and size of a self-financing subsidy very much dependent on the replacement rate and transition effect:

Deadweight Effect: The greater is the hiring rate in the initial steady state, the larger will be the deadweight implied by a hiring voucher. As can be seen in table (1), empirically, hiring rates in general increase with productivity. Thus, hiring vouchers should be targeted at workers with the lowest productivity, namely low-ability workers as well as long-term unemployed workers.

Replacement Rate Effect: As shown above, the lower the income and ability, the higher is the replacement rate. Thus, increased employment in the group with the lowest income will generate the largest reduction in government expenditures (in terms of the respective wage). Hence, the government can grant a higher voucher relative to the respective wage. Thereby, ceteris paribus, the higher is the replacement rate, the more likely is the hiring voucher to be self-financing. The replacement effect clearly favors hiring vouchers for low-ability workers.[239]

Transition Effect: If a hiring vouchers brings a worker back to work, her human capital appreciates in our model. In our model the human capital

[239] As insider bargain for the wage, long-term unemployed workers receive the wage of the respective ability class. Naturally, low-ability workers have the lowest wage.

appreciation implies that the formerly short- and long-term unemployed have the same productivity as insiders after one period. As a consequence, their low hiring probability ($\eta^{d_u}_{\alpha_a,t}$) is exchanged for a considerably higher retention probability ($1-\phi_{\alpha_a,t}$). This effect is strongest for long-term unemployed since they have been most affected by human capital loss. Thus, subsidies enabling workers to move to a higher productivity class have a bigger long-run effect on the government budget. Clearly, this effect favors hiring vouchers for long-term unemployed workers.

Summary: While the last effect is in favor of targeting long-term unemployed, the second delivers an argument for targeting low-ability unemployed and the first is ambiguous. The intuition is straightforward, hiring vouchers are more effective, the least skilled/productive the targeted workers are, i.e. the longer they have been unemployed and the lower their ability is. Which low-productivity class of workers is the most effective target group for hiring vouchers for Germany can only determined by our following numerical simulation.

7.4.3 Numerical Results

We simulate our above model for Germany, and compare the effectiveness of the following employment subsidy policies:

(i) A low-wage subsidy (σ_l) which is paid (each period) for each low-wage/ability employee. It will reduce the firing rate, by making employees more profitable for the firm. Thus, it raises the insider retention incentive, whereby the firm retains more workers with high operating costs (low productivity).(see equations (314), (313))

At the same time the hiring rate will increase since the subsidy provides the incentive to hire more low productivity workers, which would not have been hired otherwise. (see equations (317), (318) and (320), (321))

(ii) A hiring voucher targeted at low-ability workers ($\sigma^{d_u}_l$), which is paid for hiring unemployed, low-ability workers. Following the same rationale as above, the firm will hire more workers than without a voucher . In contrast to the first policy, the firing rate will not be affected since the voucher is only paid for new hires and not for the entire employment stock.(see equations (317), (318) and (320), (321))

(iii) A hiring voucher targeted at long-term unemployed workers ($\sigma^{L}_{\alpha_a}$), which is paid if a long-term unemployed worker is hired. (see equations (320), (321))

(iv) A hiring voucher targeted at the low-ability, long-term unemployed workers (σ_l^L; see equations (320), (321))

In a first step, we identify the policies which are AWE and compare their effectiveness. But as noted the self-financing criterion is the limiting factor and some policies do not satisfy this constraint. While it may not be approximately welfare efficient, it may nonetheless be desirable for policy makers to prioritize the employment and welfare creation - without increasing inequality - compared to other government tasks. Then the government allocates a positive net expenditure to these subsidies, $G > 0$. Thus, in a second step we examine the performance of the differently targeted employment subsidies (i)-(iv) with respect to the remaining two criteria, given an positive net expenditure allocation to these subsidies beyond their approximate welfare efficiency.

Approximately Welfare Efficient Targeting: Our simulation reveals that a *low-wage subsidy* is not an AWE policy for Germany. While a low-wage subsidy creates more employment and reduces inequity, it *is not self-financing*. This result is driven by the *deadweight effect* and the *wage effect*, as described above. Thus, low wage subsidies can only be implemented if the government is willing to provide extra resources permanently. We will analyze their performance in this respect below.

Furthermore, our results show that *hiring vouchers* for Germany can be self-financing and thereby AWE, depending on the target group.

To determine the most effective employment subsidy, we examine the approximately welfare efficiency of hiring vouchers targeted at the low-productivity groups, namely at long-term unemployed as well as at the low-ability unemployed, and compare their employment, welfare and equity effects.

For both groups there are two possible options for hiring vouchers (HV):

Option 1: a same lump sum voucher is paid for hiring a long-term unemployed worker (low- ability worker) irrespectively of his ability class (unemployment duration),

Option 2: a different voucher is paid for hiring a long-term unemployed worker (low- ability worker) depending on his ability class (unemployment duration).

While option 1 implies a voucher which is self-financing across ability classes (unemployment duration), option 2 (unemployment duration) is determined to be self-financing within each ability class (unemployment duration), thereby, preventing cross-subsidization across ability classes (unemployment duration).

Targeting Long-Term Unemployed: Vouchers targeted at long-term unemployed (LTU) workers are AWE for Germany. Table (2) compares the effectiveness of the two design options by describing their unemployment, welfare[240] and equity implications, the latter given by the Gini coefficient.

If a same lump sum hiring voucher is paid for all long-term unemployed compared to an ability specific payment, the self-financing restriction is hit much earlier. While only 947 € per worker are AWE in the former case, up to 4390 € (2503 €) can be paid for low-ability (medium-ability) workers in the latter (see figure (9)[241]). The intuition is straightforward: option 2 fully exploits the larger self-financing areas for long-term unemployed workers in the low-ability and medium-ability class, thereby, it prevents costly cross-subsidization. The self-financing area and thereby, the self-financing, approximately welfare efficient subsidy decreases with productivity due to a smaller *deadweight effect* and the bigger *replacement rate effect*.

By comparing the results of these two exercises, we can clearly infer that hiring vouchers of different magnitudes for each ability group deliver a superior effectiveness. They perform better in terms of unemployment reduction, welfare improvement and inequality reduction. According to our calibration the long-term unemployment among low-ability workers can be e.g. reduced by 9 percent "for free,"[242] i.e. from roughly 10 percent to 9 percent of all low-ability workers.

Targeting Low-Ability Unemployed: If a lump sum hiring voucher is targeted at all low-ability unemployed (LAU) (option 1), there is no self-financing area at all.

But as shown in figure (10)[246] differentiating the vouchers for short-term and long-term unemployed workers reveals an approximately welfare efficient hiring voucher for low-ability workers (4390 €), which though is present only for long-term unemployed workers. The reason is that short-term unemployed workers have a higher productivity than the long-term unemployed, thereby

[240] The welfare of the workforce is calculated as the sum of the utility of the workers over the various labor market states. See Appendix (7.6.3). A "+" for welfare changes indicates an increase in welfare. The cross-policy ranking of changes in welfare corresponds to the ranking of changes in overall unemployment. The utility parameter ξ does not affect the cross-policy rankings.

[241] Option 2 vouchers are differentiated in those for low-, medium- and high-ability.

[242] Without any bet allocation of government resources to this policy in the long-run.

[246] Vouchers are differentiated in those for long-term and short-term unemployed.

		HV for LTU Opt. 1	HV for LTU Opt. 2
1	**Subsidy**	**947**	**4390 / 2503 / 0**
2	**Subsidy in % of W**	**3.7 / 3.1 / 2.2**	**16.9 / 8.4 / 0**
3	% Δ of LA LTU[243]	-2.1	-8.9
4	% Δ of LAU	-0.8	-4.4
5	% Δ of LTU	-2.0	-5.9
6	% Δ of Overall U	-0.9	-2.8
7	**Change of Welfare**	+	+
8	**Gini coefficient**[244]	**11.45**	**11.41**

Table 9: AWE HV for LTU workers in design options 1 and 2 and the resulting unemployment, welfare and equity implications

		HV for LAU Opt. 2
1	**Subsidy**	**4390 / 0**
2	**Subsidy in % of respective wage**	**16.9**
3	% Δ of Low-Ability Long-Term Unemployment	-8.9
4	% Δ of Low-Ability Unemployment	-4.4
5	% Δ of Long-Term Unemployment	-2.9
6	% Δ of Overall Unemployment	-1.4
7	**Change of Welfare**	+
8	**Gini coefficient**[245]	**11.45**

Table 10: AWE HV for LAU workers in design option 2 and the resulting unemployment, welfare and equity implications

a higher hiring rate, which implies a higher *deadweight effect* and a smaller *transition effect*. Both impede a self-financing are for these workers.

Clearly, AWE hiring vouchers for long-term unemployed workers - in their more effective option 2 targeting - nest the AWE hiring vouchers for low-ability workers - in option 2 targeting -, which is a special hiring voucher for low-ability, long-term unemployed workers.

Thereby, it is worth emphasizing that thus, for Germany targeting vouchers at long-term unemployed workers (targeted at the low- and medium-ability workers) is more effective than targeting low-ability workers.

Overall, it has to be mentioned that the size of the approximately welfare efficient subsidy depends crucially on the hiring elasticities. We claim that they can be influenced substantially by policy makers. Designing a successful subsidy system should include complementary measures[247], such as tightening unemployment benefits or firing costs, improving job placement or increasing the pressure to accept job offers, to ensure the aforementioned simulated or even better long run effects.

Employment-Equity Trade-Off Interestingly, the self-financing hiring voucher reduces the economy's unemployment and inequity at the same time. Thus, a hiring voucher does not face an employment-equity trade-off. It is possible to improve at both ends. This is all the more interesting since other simulated policy measures, such as a reduction of the replacement rate for the low-ability workers (which are the most unemployment prone) would buy more employment at the cost of a higher Gini coefficient; thus facing an employment-equity trade-off.

Displacement Effects The critical reader may wonder if our results differ significantly if we consider displacement (and not only deadweight) effects in our model. The simplest way to incorporate them are short-run decreasing returns to labor under fixed capital. When labor input is increased by factor x (with $x > 1$), under a Cobb-Douglas function $Y = AN^{1-\alpha}\bar{K}^{\alpha}$ we would obtain the following marginal product: $\partial Y/\partial N = x^{-\alpha}(1-\alpha)AN_0^{-\alpha}\bar{K}^{\alpha}$. If the labor input increases by 1 percentage point (which corresponds roughly to a 1 percentage point reduction of unemployment), the marginal product would decrease by 0.3 percentage points (assuming a capital share of 33 percent for Germany, see Statistisches Bundesamt, 2006). This would reduce the wage

[247] See Coe and Snower (1997) and Orszag and Snower (1998).

claim of the insiders, but nevertheless reduce the profit of the firm somewhat. The AWE hiring vouchers for low-ability, long-term unemployed workers is reduced from 17 to 15 percent by this exercise. Thus, our results are not affected qualitatively and only slightly quantitatively. Furthermore, we consider displacement to be rather a short-run phenomenon because capital adjusts in the long-run.[248]

Relaxing the Self-Financing Constraint: Approximately welfare efficient policies can contribute to reduce the unemployment, but according to our calibration they would surely not be sufficient to bring Germany back to full employment. Thus, we analyze the performance of differently targeted subsidies, once we go beyond the approximately welfare efficient subsidy.[249] We define a policy measure to outperform the other policies if it delivers the biggest marginal effects in terms of the two remaining policy objectives for a given additional amount of government spending.

Specifically, we assume that in the long-run the government is willing to allocate a net expenditure of € 50 ($G = 50$, per year and per person of the workforce[250]) for active labor market policies.[251] Note that the gross amount of money which is additionally allocated to the policies is larger since part of the additional expenses are financed by additional revenue, generated by resulting higher employment levels. These expenditures are allocated to the targeted groups by increasing the subsidy (in equal Euro steps for all targeted groups) until the (new steady state's) budget constraint is reached.

Figure (11)[253] presents the implications for the government's objectives unemployment and inequality of this marginal exercise beyond the AWE subsidy, comparing hiring vouchers for long-term unemployed (LTU) and for low-ability

[248] Although our quantitative analysis above omits displacement effects, we consider our calibration to be rather conservative (with respect to the size of the approximately efficient subsidy). While we used a tax rate (6.9 percent) to balance the budget (financing unemployment related expenses), in reality other taxe revenue would also increase with the employment rate. This would raise the self-financing, and thereby approximately efficient subsidy and thus lead to a higher effectiveness (in terms of employment, welfare and inequality).

[249] However, we do not calculate a welfare measure for this exercise since the government either has to cut other spending positions (which may reduce the agents' utility) or create government debt (which has to be paid by future taxes).

[250] The number has to be interpreted as a real value.

[251] For Germany with a workforce of roughly 40 million, this would amount to about 2 billion Euro. This amount, G might reflect, as noted, a budget deficit or savings in other areas.

[253] Vouchers for LTU are differentiated in those for low-, medium- and high-ability, vouchers for LAU in those for long-term and short-term unemployed.

	HV for LTU[252]	**HV for LAU**	**LWS**
Total Subsidy (% of wage)	**51.7/38.5/20.5**	**64.6 / 47.7**	**1.5**
Additional Subsidy	9033	12363	403
% Marginal Δ of LAU	-7.8	-18.7	-1.5
% Marginal Δ of LTU	-15.1	-11.4	-0.8
% Marginal Δ of U	-7.1	-5.3	-0.4
% Total Δ of LAU	**-11.8**	**-22.3**	**-1.5**
% Total Δ of LTU	**-20.1**	**-14**	**-0.8**
% Total Δ of U	**-9.7**	**-6.6**	**-0.4**
Gini coefficient	**11.29**	**11.38**	**11.32**

Table 11: Unemployment and inequality effects of HV for LTU and LAU workers - in design option 2 - and LWS beyond their AWE, i.e. with a net allocation of government expenditure of 50 Euro per worker

(LAU) workers and low-wage subsidies. The marginal unemployment reduction refers to the approximately welfare efficient steady state, i.e. the steady state with the respective AWE subsidy, whereas the total reduction is calculated with respect to the old steady state.[254]

Employment Effects: For the same two reasons as mentioned above, low wage subsidies perform worse in reducing unemployment: First of all, the *deadweight effect* is quite substantial.

While the hiring voucher targeted at the long-term unemployed is paid to roughly 2.2 percent of the overall working population, it is almost 13.6 percent for low-wage subsidies; indicating a much larger *deadweight* for the latter. Furthermore, as noted, there is a considerable *wage effect*: the subsidy is not used entirely to improve the employment incentive of the firm (and thus increase employment). Part of it goes directly to the employed workers since it affects the bargaining.

For these two reasons low-wage subsidies underperform in relative terms: 99.7 percent of the recipients get the subsidy, although they would also have been employed in the absence of a subsidy. The ratio is quite big for hiring vouchers targeted at long-term unemployed (68.5 percent) as well; nevertheless considerably smaller. Thus, in contrast to low-wage subsidies, hiring vouchers (targeted at long-term unemployed, see column one of table (4), or the low-ability unemployed, see column two) come along with a substantial size per

[254] Naturally, as low-wage subsidies are not approximately efficient, the marginal reduction is equal to the overall.

subsidized worker (for a given net government allocation) and deliver a bigger employment effect.[255]

Again, also in this marginal exercise for Germany, the hiring voucher targeted at low-ability unemployed workers is outperformed by the one targeted at long-term unemployed workers: in terms of the marginal reduction as well as the overall reduction of total unemployment. Besides the *transition effect*, another reason can be found in the employment dynamics equation (322). In our model it is much easier to obtain small employment effects for a given ability group compared to a large effect, i.e. labor demand elasticities are bigger, the smaller the marginal expenses are.[256] The hiring voucher for low-ability, long-term unemployed is larger if the given net expenditure is exclusively targeted at low-ability workers (64.6 percent, see column two of table (1)) compared to targeting it exclusively at long-term unemployed (51.7 percent, see column one of table (4)). As a consequence, the labor demand elasticity (in absolute values) in the former case is smaller than in the latter.

Thus, it is a better strategy to focus a given net expenditure on long-term unemployed workers in different ability classes, compared to restricting the hiring voucher only to the low-ability unemployed. Our simulation indicates that a policy which is targeted at long-term unemployed and which has the aforementioned size could cut long-term unemployment by 20 percent and overall unemployment by roughly 10 percent.

Equity Effects: While our model shows that hiring vouchers are a much better instrument to reduce unemployment than low wage subsidies, the answer is more ambiguous with respect to equity. The Gini coefficient improves for wage subsidies and hiring vouchers; even somewhat more for hiring vouchers. But there are two countervailing effects at work:

The low-wage subsidies are targeted at two groups which are at the lower end of the income scale (low-ability unemployed and employed) and improve their income via the bargaining mechanism. As the low-ability insiders bid for a higher wage, the income of the low-ability workers increases (while their employment increases somewhat too), namely wages and indirectly benefits.

While the hiring vouchers are not as clearly targeted at the "poorest"

[255] All calculations are based on the new steady state. To provide a fair comparison, the approximately welfare efficient part of the hiring subsidies is not taken into account.

[256] This is most easy to see under homogenous labor where the long-run employment is equal to $n = \frac{\eta}{\eta+\phi}$ (see chapter 6). The marginal employment effect of an increasing hiring rate obviously is posive, but decreasing ($\frac{\partial n}{\partial \eta} > 0, \frac{\partial^2 n}{\partial \eta^2} < 0$).

groups (also hiring of high-ability long-term unemployed is subsidized) and do not have a direct wage effect, their incentive effect is much bigger. They improve equality by bringing the long-term unemployed back to work: In contrast to that low-wage subsidies do so by putting money in the pockets of low-income people (without generating much additional employment).

Hiring vouchers for long-term unemployed workers reduce inequality by more compared to hiring vouchers for low-ability workers, as they have bigger employment effects.

Low wage subsidies can be considered to be an instrument which is in between unemployment benefits and hiring vouchers in terms of their employment-equity trade-off. While higher unemployment benefits for the low-ability workers can improve equity (giving more money to the poorest in our model: the low-ability unemployed), they destroy the firm's employment incentives (via wage bargaining, as the workers' fallback position increases) and thus increase unemployment. For a given budget constraint low-wage subsidies improve employment incentives only slightly but increase the income of low-income workers. And hiring vouchers increase employment incentives substantially, thus reducing inequality by bringing people back into work; thus yielding less unemployment and more equity at the same time.

7.5 Concluding Thoughts

This chapter has proposed a new criterion for the evaluation of employment subsidies: approximately welfare efficient (AWE) policies are self-financing and improve employment/welfare, without increasing earnings inequality. Policies satisfying this criterion can be expected to be particularly attractive to policy makers. We have compared various popular employment subsidies on this basis. Needless to say, approximate welfare efficiency is a highly conservative criterion; policy makers may well wish to implement measures that are not AWE, but in that case they need to move along an equity-efficiency trade-off (viz., they need to sacrifice either employment/welfare or earnings equality[257]).

Our analysis indicates that the employment policies under consideration exhibit diminishing returns, in that equal incremental increases in each employment subsidy lead to progressively smaller increases in employment/welfare and require progressively larger net government expenditures on the subsidies, for a given upper bound on earnings inequality. Once a critical level

[257] An increase in the net government budgetary allocation for the employment subsidy would naturally also require such an sacrifice, in an intertemporal sense.

of each subsidy is exceeded, it is no longer self-financing.[258] Furthermore, for our model, the self-financing constraint becomes binding before employment/welfare begins to decline or inequality begins to increase. Thus, the critical subsidy level identifies the magnitude of the subsidy that is maximally effective, i.e. it creates maximal employment/welfare while remaining AWE. For a variety of employment subsidies, differing in terms of their target groups, the maximal employment effects of AWE policies may be calculated, and the subsidies may be ranked on this basis.

In the context of our labor market model, calibrated for Germany, we have shown that low-wage subsidies (targeted at low-income/ability workers) are not AWE, i.e. no positive low-wage subsidies are self-financing. By contrast, hiring vouchers can be AWE. Our calibrated model lead to an unambiguous ranking of these hiring vouchers: hiring subsidies for the long-term unemployed are more effective than hiring vouchers for low-income/ability workers. The same ranking, in terms of employment, holds for employment subsidies financed through government expenditures extending beyond the AWE limit.

While these results are striking, it is worth emphasizing that are specific to our German calibration. Our model permits an analysis of the determinants of AWE policies. Thus it provides a groundwork for future research comparing employment subsidies in different countries.

[258] Of course, the critical level can be zero, in which case the subsidy is never self-financing.

7.6 Technical Appendix

7.6.1 Linearization

Firing Rate: Non-linear equation:

$$\phi_{\alpha_a} = 1 - \Gamma_{\alpha_a}\left(\frac{a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a} - \phi_{\alpha_a} f_{\alpha_a}\delta}{1-\delta\left(1-\phi_{\alpha_a}\right)} + f_{\alpha_a}\right), \tag{326}$$

where σ_{α_a} is a wage subsidy for ability class α_a. Linearization:

$$\phi_{\alpha_a,new} = \phi_{\alpha_a,0} -_{\phi} \Gamma'_{\alpha_a,0}\left[\frac{1}{1-\delta\left(1-\phi_{\alpha_a}\right)}\right]_0 \tag{327a}$$

$$\frac{1}{1+V_{\alpha_a}}\left[\begin{array}{c}\left(a^I_{\alpha_a,new} - w_{\alpha_a,new} + \sigma_{\alpha_a}\right)\\ -\left(a^I_{\alpha_a,0} - w_{\alpha_a,0}\right)\end{array}\right] \tag{327b}$$

$$-_{\phi} \Gamma'_{\alpha_a,0}\left[\frac{-\phi_{\alpha_a}\delta}{\left(1-\delta\left(1-\phi_{\alpha_a}\right)\right)} + 1\right]_0 \frac{1}{1+V_{\alpha_a}}\left(f_{\alpha_a,new} - f_{\alpha_a,0}\right) \tag{327c}$$

with

$$V_{\alpha_a} =_{\phi} \Gamma'_{\alpha_a,0}\left[\frac{\delta\left(f_{\alpha_a}(\delta-1) - \left(a^I_{\alpha_a} - w_{\alpha_a}\right)\right)}{\left(1-\delta\left(1-\phi_{\alpha_a}\right)\right)^2}\right]_0$$

where variables with subscript "0" are at the old steady and variables with subscript "new" are at the new steady state.

Hiring Rates: Non-linear equation:

$$\eta^S_{\alpha_a} = \Gamma_{\alpha_a}\left(\begin{array}{c} a^{E1}_{\alpha_a} - w_{\alpha_a} + \sigma^S_{\alpha_a} + \sigma_{\alpha_a} + \\ \frac{\delta\left(1-\phi_{\alpha_a}\right)\left(a^I_{\alpha_a} - w_{\alpha_a} + \sigma_{\alpha_a}\right) - \phi_{\alpha_a} f_{\alpha_a}\delta}{1-\delta\left(1-\phi_{\alpha_a}\right)} - h_{\alpha_a}\end{array}\right), \tag{328}$$

where $\sigma^S_{\alpha_a}$ is the hiring voucher for short-term unemployed workers of ability class α_a.

Linearization:

$$\eta^S_{\alpha_a,new} = \eta^S_{\alpha_a,0} +_\eta \Gamma'_{\alpha_a,0}\left[\left(a^{E1}_{\alpha_a,new} - w_{\alpha_a,new} + \sigma^S_{\alpha_a} + \sigma_{\alpha_a}\right) - \left(a^{E1}_{\alpha_a} - w_{\alpha_a,0}\right)\right] \tag{329a}$$

$$+_\eta \Gamma'_{\alpha_a,0}\left[\frac{\delta\left(1-\phi_{\alpha_a}\right)}{1-\delta\left(1-\phi_{\alpha_a}\right)}\right]_0 \left[\begin{array}{c}\left(a^I_{\alpha_a,new} - w_{\alpha_a,new} + \sigma_{\alpha_a}\right)\\ -\left(a^I_{\alpha_a,0} - w_{\alpha_a,0}\right)\end{array}\right] \tag{329b}$$

$$-_\eta \Gamma'_{\alpha_a,0}\left[\frac{\phi_2\delta}{1-\delta\left(1-\phi_2\right)}\right]_0 \left(f_{\alpha_a,new} - f_{\alpha_a,0}\right) \tag{329c}$$

$$-_\eta \Gamma'_{\alpha_a,0}\left(h_{\alpha_a,new} - h_{\alpha_a,0}\right) \tag{329d}$$

$$+_\eta \Gamma'_{\alpha_a,0}\left[\frac{-\delta\left(\left(a^I_{\alpha_a} - w_{\alpha_a}\right) + f_{\alpha_a}\left(1-\delta\right)\right)}{\left[1-\delta\left(1-\phi_{\alpha_a}\right)\right]^2}\right]_0 \left(\phi_{\alpha_a,new} - \phi_{\alpha_a,0}\right) \tag{329e}$$

And equivalently for the second unemployment duration group.

7.6.2 Ability Group Specific Numbers

Replacement Rate: To calculate the replacement rate for each ability group, we used the net replacement rates from OECD (2006). To obtain ability-specific numbers, the 67% average productivity worker (APW), 100% APW and 150% APW were chosen to represent the low, medium and high-ability group in our model, respectively. For simplicity, we took the unweighted average across six family types as well as over the initial period of unemployment and long-term unemployment.

Labor Costs: The aggregate producer wage and gross value added per worker can be obtained from Statistische Ämter des Bundes und der Länder (2006).

The aggregate producer wage is defined as the average real gross wage per employee plus social security payments. We took the 2003 values for real labor costs (50334 Euros) and gross value added (32672 Euros) since the OECD numbers which we used for further calculations were only available until this point in time.

Using the wage equation (109)[259], we calculated the average bargaining

[259] Note that all the calculations are done for $\xi = 1$ in the utility function ($\upsilon(c) = c^\xi$). This is without loss of generality. The model results for hiring vouchers are not affected at all by differing ξ, except of course for the welfare calculations, which we show for $\xi = 0.5$ and $\xi = 1$. However, for low wage subsidies the wage formation would be affected and thus

	low-skilled	medium-skilled	high-skilled	aggregate
l_s	16.6	59.4	24	100
w_s	26019	30022	44220	32672
a_s^I	31179	47012	75069	51109
a_s^{E1}	28345	42738	68244	46462
a_s^{E2}	22676	34190	54595	37170

Table 12: Relevant labor cost values

power in the economy, where the variables denote aggregate values:

$$w = (1-\mu)\, rr * w + \mu\,(a + \rho w) \tag{330}$$

$$\mu = \frac{w - rr * w}{a + \rho w - w * rr} \tag{331}$$

We obtain $\mu = 0.204$.

Ability group specific relative labor costs for Germany are calculated as follows (OECD, 2005c): High-ability workers earn 148 percent of their medium-ability counter-parts' wage and low-ability 87 percent, respectively.[260] Low-ability workers' highest education level is lower secondary education, whereas it is upper secondary education or post-secondary non-tertiary education for medium-ability and tertiary education for high-ability.

Assuming that the bargaining power is the same in all ability groups and using the respective replacement rates[261] we get for each ability group α_a

$$a^I_{\alpha_a} = \frac{w_{\alpha_a} - \left(1 - \mu_{\alpha_a}\right) rr_{\alpha_a} w_{\alpha_a} - \mu_{\alpha_a} \rho w_{\alpha_a}}{\mu_{\alpha_a}} \tag{332}$$

Figure (12) summarizes the relevant values.

7.6.3 Welfare of the Workforce

The welfare (Ω) of the workforce is calculated as the sum of the utility of the workers over the various labor market states.

the results would change slightly. The cross-subsidy rankings with respect are though not affected by this specification of the utility function.

[260] Similar relations can be found in Wienert (2006).

[261] Furthermore, we assumed that the firing costs are 60 percent of the labor costs, see Chen and Funke (2003).

$$\Omega_t = \sum_{\alpha_a} \upsilon(w_{\alpha_a,t}(1-\tau)) l_{\alpha_a} n_{\alpha_a} + \sum_{\alpha_a} \sum_{d_u} \upsilon\left(b_{\alpha_a}\right) u_{\alpha_a}^{d_u} l_{\alpha_a} \tag{333}$$

8 Conclusion

Mankiw (1990) compares the recent developments in macroeconomics to the Copernican revolution. "Compared to the then prevailing geocentric system of Ptolemy, the original Copernican system was more elegant and, ultimately, it proved more useful. But at the time it was proposed and for many years thereafter, the Copernican system did not work as well as the Ptolemaic system. For predicting the positions of the planets, the Ptolemaic system was superior." (Mankiw, 1990, p. 1646) Almost 20 years after Mankiw has written these lines, his critique has probably become obsolete. Medium scale models (e.g., Christiano et al., 2005, Smets and Wouters, 2003) can predict the dynamic adjustment paths in response to macroeconomic shock fairly well and are able to produce similar theoretical impulse response functions as the empirical counterparts from Vector-Autoregressions. Thus, there is no longer a reason to resort to traditional ad-hoc models due to their better empirical performance.

However, there are still some parallels to the Copernican revolution. "At the time, he [Copernicus] mistakenly thought that the planets followed circular orbits; we now know that these orbits are actually elliptical." (Mankiw, 1990, p. 1646) The form of the orbits resembles to the microstructure of current state of the art macroeconomic models. To obtain empirically realistic impulse response functions, business cycle modelers add several ad-hoc assumption on a microeconomic level, which cannot be observed in reality, for example, habit formation, indexation to inflation and artificial timing assumptions.

This dissertation starts (chapter 2) by pointing out the path to modern macroeconomics and remaining weaknesses. Afterwards (chapter 3), a standard New Keynesian business cycle model is linearized around a zero inflation steady state and it is shown that the interaction of price and wage staggering is complementary in terms of "quantitative persistence." Next, the thesis analyzes the effects of real wage rigidities on a disinflation, pointing out the importance of non-linearities, which arise due to the non-superneutrality[262] of money in this class of models (chapter 4). These non-linearities are often ignored in the existing literature.

In the second building block (chapters 5 to 7), a new micro-founded macro-labor framework is developed and applied to different policy problems. We

[262] Money is neutral if increases in the money supply do not have any permanent effects, while it is super-neutral if changes in the money growth rate do not have any long-run effects.

show that market frictions, such as labor turnover costs and wage bargaining, have important implications for macroeconomic performance and for the implementation of different labor market policies. Many of these market frictions have so far often been analyzed in static framework or they have been completely ignored, especially by the mainstream New Keynesian literature.

Recently, there is a promising stream of research which combines labor market frictions and the New Keynesian workhorse model (e.g., Blanchard and Galí, 2006, Christoffel and Linzert, 2005, Krause and Lubik, 2007, and Trigari, 2004). However, all the aforementioned papers use the mainstream search and matching equilibrium unemployment approach. As discussed in chapter 2, the search and matching model is very ad hoc and thus potentially subject to the famous Lucas (1976) Critique.

In terms of Mankiw's comparisons to the Copernican revolution, modern macroeconomic researchers have not only recognized that the Ptolemaic system (old neo-classical synthesis) is not superior. They also know that planets do not follow circular orbits (the existing micro-structure of macroeconomic models is far from perfect, especially with respect to the labor market structure). The appropriate micro-structure[263] for macroeconomic models remains a challenging question for future research.

As a consequence, research at the intersection of labor and monetary economics can be expected to be very stimulating during the next couple of years. Hopefully, in a decade from now, macroeconomists will have agree on a more convincing micro-structure for medium scale macroeconomic models than we have it nowadays (corresponding to the discovery of the elliptical orbits). A more comprehensive framework may be useful for the evaluation of a wide set of different policies.

Blinder (1997, p. 17) states: "Having looked at monetary policy from both sides now, I can testify that central banking in practice is as much art as science. Nonetheless, while practicing this dark art, I have always found the science useful." The better economists get the micro-structure of macroeconomic models fixed, the more reliable they will be able to predict welfare implications and adjustment costs of different policies and the more seriously they will be taken by policy makers. In this sense, an appropriate micro-

[263] Mankiw and Reis (2002) propose an alternative approach to sticky prices ("sticky information"), which is based on slow information dissemination (a detailed analysis goes beyond the scope of this thesis). For the simulation in a general equilibrium model and the microfoundations of "sticky information" see Mankiw and Reis (2007) and Reis (2006a, b). The fact that firms review prices more often than they change them raises objections against this approach (see Blanchard and Galí, 2007, and Fabiani et al., 2005).

structure may be crucial for the relative importance of the components "dark art" and science, in central banking as well as in other government policies.

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5/2001 – present: Scholarship of e-fellows.net

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Research Papers:

Journal Articles:

- "The Effect of Capital Requirement Regulation on the Transmission of Monetary Policy: Evidence from Austria," with Engler, P., Jokipii, T., Rovira-Kaltwasser, P. and Vinhas de Souza, L., Empirica, forthcoming.

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Working Papers:

- "Real Wage Rigidities and the Cost of Disinflations: A Comment on Blanchard and Galí," with Ascari, G., Kiel Working Paper, No. 1312, February 2007.

- "Escaping the Unemployment Trap - The Case of East Germany-," with Snower, D., Kiel Working Paper, No. 1309, January 2007.

- "Comparing the Effectiveness of Employment Subsidies," with Brown, A. and Snower, D., Kiel Working Paper, No. 1302, November 2006.

- "Banks' Regulatory Buffers, Liquidity Networks and Monetary Policy Transmission," with Stolz, S., Bundesbank Discussion Paper, Series 2: Banking and Financial Studies, No. 06/2006, August 2006.

- "Monetary Persistence, Imperfect Competition and Staggering Complementarities," with Snower, D., CEPR Discussion Paper, No. 5658, May 2006.

Light Reading:

- "Einstellungsgutscheine effektiver als Kombilöhne," with Brown, A. and Snower, D., ifo Schnelldienst, No. 4/2007, pp. 37-41.

- “Besser als Kombilöhne. Gastanalyse: Gutscheine für Langzeitarbeitslose,” with Brown A. and Snower, D., Die Welt, 10 November 2006.

Conferences and Workshops:

Presentations:

- 10th European IZA Summer School, Buch am Ammersee, April 2007
- Internal seminar “Science meets Politics” at the German Federal Ministry of Economics and Technology, Berlin, March 2007
- Macroeconomic Research Meeting, ETH Zürich, Zürich, February 2007
- Internal workshop at the German Federal Ministry of Finance, Berlin, December 2006
- Annual meeting of the Verein für Socialpolitik (German Economic Association), contributed session and invited panel session, Bayreuth, September 2006
- Annual Meeting of the European Economic Association, Vienna, August 2006
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- Joint Bundesbank-IfW seminar at the Deutsche Bundesbank, Frankfurt, June 2006
- Workshop on “Financial Stability” at the Deutsche Bundesbank, Frankfurt, December 2005
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Referee Service:

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Ich erkläre hiermit an Eides Statt, dass ich meine Doktorarbeit „Monetary and Labor Policies under Market Frictions" selbstständig angefertigt habe und dass ich alle von anderen Autoren wörtlich übernommenen Stellen, wie auch die sich an die Gedanken anderer Autoren eng anlehnenden Ausführungen meiner Arbeit, besonders gekennzeichnet und die Quellen zitiert habe.

Kiel, Mai 2007